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Alan Woods
Ted Grant

**Dialectical
Philosophy
and Modern
Science**

**REASON
IN
REVOLT**

Volume II

Algora

REASON IN REVOLT

VOLUME II

REASON IN REVOLT

DIALECTICAL PHILOSOPHY

AND

MODERN SCIENCE

Volume II

Ted Grant

&

Alan Woods

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PREFACE

TO THE SECOND VOLUME OF THE AMERICAN EDITION

The first volume of *Reason in Revolt* has, by all accounts, been well received in the USA. This is a matter of very great satisfaction to Ted and myself. In general, the Anglo Saxon world has been highly resistant to broad philosophical generalizations and to Marxism in particular. Yet without such philosophical generalizations it is impossible to acquire a rational understanding of the world in which we live.

The word “philosophy” was first supposed to have been used by Pythagoras in the sixth century BC: “Life, he said, is like a festival; just as some come ... to compete, some to ply their trade but the rest come as spectators, so in life, slavish men go hunting for fame or gain, the philosophers for truth.” (Diogenes Laertius, 14.)

In the search for truth the human race has come a very long way in the 2,500 years or so since then. The development of the productive forces — industry, agriculture, science and technology — has reached levels that would have been undreamed of in the past. This advance has been most spectacular in the USA.

The development of the productive power of society should be a guarantee of happiness for all humanity. Yet the world has never been such a disturbed and unhappy place as it is at the start of the 21st century. War, unemployment, poverty, disease and hunger stalk the planet.

Our world is rent by a fundamental contradiction. It is the contradiction between “ought” and “is” — between what is possible and what is real. In this world of ours 476 billionaires — mostly Americans — have a greater personal wealth than the total income of half the world’s population, while 35 million people starve to death every year.

This is a world governed by an outdated and irrational economic order that ought to have been abolished long ago, but which refuses to die and condemns the world to new torments with every passing day.

It is therefore hardly surprising that the prevailing mood of humanity at the dawn of the new millennium is one of deep pessimism and anxiety. Men and women do not look forward to the future with confidence as they used to. That spirit of cheerful optimism that used to be a characteristic of American people has vanished and in its place there is a bleaker, but also a more thoughtful mood.

Materialism Versus Mysticism

In such times as these, mystical tendencies tend to predominate in philosophy, and the present period is no exception. *Reason in Revolt* was written in part to combat the intrusion of mystical philosophical ideas in science. This is a retrograde trend that runs counter to the progressive tendency that has propelled the whole development of science from its inception.

In fact, the link between science and philosophy goes back a long way. The early Greek philosophers were materialists who laid the basis for all science. They studied the causes of natural phenomena like lightening, thunder, earthquakes, comets and stars. For all these phenomena they sought rational explanations, free from the intervention of gods and other supernatural agencies.

Cicero (in *Tusculan Disputations*) wrote that the early Greek philosophers studied “number and movement, and the source from which all things arise and to which they return; and these early thinkers inquired zealously into magnitude, intervals, and courses of the stars, and all celestial matters.”

That is to say, the pre-Socratic philosophers studied *nature*. They were the courageous pioneers who prepared the way for all subsequent scientific advance. They made extremely important discoveries. They knew that the earth was round and that the moon’s light reflected that of the sun. They knew that humans were descended from fish and proved it by examining human embryos and fossils. However, most of these discoveries were the result of inspired

guesswork. Inevitably at a certain stage they came up against the limitations related to the given level of technology.

After this, philosophy took a different turning — towards the study of human society, morality and related questions. This led to the development of idealism and ever since then philosophy has been split into the two great warring camps of materialism and idealism. The Middle Ages were marked by the cultural and spiritual dictatorship of the church which imposed its own ossified brand of idealism on men's minds and burned those who disagreed at the stake. The Renaissance and the rise of the bourgeoisie saw a revival of materialism and a new interest in experiment and observation that permitted science, feed from the fetters of religion, to advance once more.

Materialist philosophy and science have always marched hand in hand. From the time the early materialist philosophers of the Ionian Islands sought a rational explanation of nature without the intervention of the gods, science and philosophy were inextricably connected. In the ancient world, from where all our science is ultimately derived, we have the painstaking investigations of Aristotle into nature. The French philosopher Descartes has a strong claim to be the founder of the modern scientific method, while Bacon in England pioneered the method of experimental science and induction (generalizing on the basis of observed facts).

The input of philosophy into science has been considerable. The German philosopher Leibnitz can claim to have discovered the integral and differential calculus (although Newton may have discovered it at the same time). It therefore does not surprise us that when Newton published his great work in 1687 he called it *The Mathematical Principles of Natural Philosophy*. Kant first advanced the hypothesis that the solar system had evolved out of a rotating gas nebula. And when Dalton introduced the modern concept of the atom into chemistry, he had his book published under the title *A New System of Chemical Philosophy*, (1808).

Science and Philosophy

Nowadays many scientists treat philosophy with contempt. It must be admitted that as far as modern philosophy is concerned this is well deserved. For the past one and a half centuries the realm of philosophy resembles an arid desert with only the occasional trace of life. The treasure trove of the past, with its ancient glories and flashes of illumination seems utterly extinguished. Not only

scientists but men and women in general will search in vain in this wasteland for any source of enlightenment.

Yet on closer inspection the contempt displayed by scientists to philosophy is not well grounded. For if we look seriously at the state of modern science — or more accurately its theoretical underpinnings and assumptions, we see that science has in fact never freed itself from philosophy. Unceremoniously expelled by the front door, philosophy slyly effects a re-entry through the back window.

Scientists who proudly assert their complete indifference to philosophy in reality make all kinds of assumptions that are philosophical in character. And in fact, this kind of unconscious and uncritical philosophy is not superior to the old fashioned kind but immeasurably inferior to it. Moreover, it is the source of many errors in practice. The idea that it is possible to dispense altogether with theoretical generalizations and limit oneself to “the facts” is a mistake, for the facts do not select themselves.

Serious difficulties arise when scientists use inadequate philosophical tools that, instead of helping, make it more difficult to gain such a rational insight. Unfortunately, for many decades the kind of philosophy taught in universities has been based on false and misleading theories such as logical positivism, which under one guise or another has been the dominant philosophical trend particularly in the Anglo-Saxon countries for most of the 20th century.

The meager content of this school of thought did not prevent its adherents from assuming the most arrogant airs and graces, reserving for themselves the stately title of “philosophers of science.” However, this positivist love affair with science was by no means met with corresponding zeal from those active in the field:

“Some remarkable conclusions were reached,” writes Derek Gjertsen. “Electrons ceased to exist and became logical constructions created out of meter readings and tracks on photographic plates. Laws of nature were rejected as empirical truths and described instead as rules for finding out about reality. The problem of induction was transformed into a new discipline of confirmation theory and, amidst a plethora of paradoxes, much time was spent by inductive logicians considering the logical complexities of the proposition ‘All crows are black.’”

The obsession of the positivists with an imaginary “structure of science,” the fiddling and fussing about meaning and semantics all strikingly resembled the rarified atmosphere and convoluted debates of the medieval Schoolmen. The

intolerable pretensions of the high priests of logical positivism eventually led to rejection and revolt on the part of the scientists themselves.

There is, however, a deeper reason for the neglect of philosophy in the scientific community. The remarkable advances of science over the past century seem to have made philosophy redundant. In a world where we can penetrate the deepest mysteries of the cosmos and follow the complex motions of subatomic particles, the old questions which absorbed the attentions of philosophers have been resolved. The role of philosophy has been correspondingly reduced. However, there are two areas where philosophy retains its importance, and which can greatly assist the work of scientists: *formal logic and dialectics*.

Dialectics and Chaos Theory

The importance of formal logic is generally accepted as a means of establishing elementary distinctions between one thing and another — of distinguishing black from white. However, the important revolution in thought that was pioneered by Heraclitus and Zeno and which reached its highest expression in the writings of Hegel and was finally placed on a scientific basis by Marx and Engels, has never been given the recognition it deserved.

The reason for this conspiracy of silence about dialectics lies outside the realm of philosophy. It is a purely political phenomenon. Since Marxism is well known to be a revolutionary world outlook that is fundamentally opposed to the existing capitalist order, and since the philosophy of dialectical materialism is well known to be the theoretical foundation of Marxism, it was considered a taboo subject.

Insofar as dialectics was ever mentioned in university text books it was always dismissed contemptuously as a semi-mystical dogma with no application to the world in general, and to science in particular. However, startling developments in modern science have provided the most striking confirmation of the dialectical method, which turns out to have a very great relevance to all aspects of science, and particularly to the cutting edge of modern science.

Hegel wrote that what is required in a scientific approach is not the mere accumulation of facts, but *the wish for a rational insight*. Dialectics provides just such an insight, and this has been brilliantly confirmed by recent investigations in an area of chaos theory known as *ubiquity*. This strongly suggests that *dialectics underlies everything*.

In his fascinating book *Ubiquity* (published by Phoenix, London, 2001), Marc Buchanan provides a wealth of information drawn from fields as widely different as the physics of phase transitions, the geology of earthquakes, stock exchange crises, the laws governing the extinction of species, wars and revolutions, forest fires, animal populations, the development of scientific theories and even fashions, to show that the same basic laws are at work in all of them.

This is a breathtaking conclusion! It would seem incredible that phenomena so diverse could obey the same simple mathematical laws, and yet it is the case. All of them seem to obey the same law, known as a *power law*, which can be expressed mathematically. Let us quote Marc Buchanan:

“The roots of war are to be sought in politics and history, those of earthquakes in geophysics, of forest fires in patterns of weather and in the natural ecology, and those of market crashes in the principles of finance, economics, and the psychology of human behavior. Beyond the labels ‘disaster’ and ‘upheaval’, each of these events erupted from the soil of its own peculiar setting. Still, there is an intriguing similarity. In each case, it seems, the organization of the system — the web of international relations, the fabric of the forests or of the earth’s crust, or the network of linked expectations and trading perspectives of investors — made it possible for a small shock to trigger a response out of all proportion to itself. It is as if these systems had been poised on some knife-edge of instability, merely waiting to be set off.” (Mark Buchanan, *Ubiquity*, pp. 9-10.)

This will be very familiar to anyone with a knowledge of dialectical philosophy, and in particular that most profound law, the law of the transformation of quantity into quality. This states that a series of small alterations (quantitative change) eventually leads to a qualitative leap. We see this in a very large number of examples at all levels in nature, human thought and history. These lines completely vindicate the assertion of Engels that “*in the last analysis nature works dialectically*.”

The field of science which we are dealing with here is known as *non-equilibrium statistical physics*. However, it is now quite clear that networks of all kinds — atoms, molecules, species, people, and even ideas “have a marked tendency to organise themselves along similar lines. On the basis of this insight, scientists are finally beginning to fathom what lies behind tumultuous events of all sorts, and to see patterns at work where they have never seen them before.” (Ibid., p. 14.)

Dialectics and the World Today

The phenomena that have caused such a stir in the scientific community involved in chaos theory and its offshoots are really not new. Hegel already dealt with them in great detail in his *Science of Logic*. He referred to this as the nodal line of measurement, where small quantitative changes give rise to great qualitative leaps. And this phenomenon is by no means confined to nature, but can also be observed in society, and even in the history of science as Thomas Kuhn so clearly showed in his acknowledged masterpiece *The Structure of Scientific Revolution*.

Engels defined dialectics as “the most general laws of motion of nature, human society and human thought.” A careful study of world history will reveal the same kind of processes that have been observed in all the other fields mentioned above. We see long periods where nothing much seems to happen (“stasis”) which are suddenly interrupted by events of a cataclysmic character: wars and revolutions.

In the last analysis, the rise and fall of different socio-economic systems is determined by their ability to develop the productive forces, the real basis upon which human progress takes place. Once a given society proves unable to develop the productive forces as it did in the past it enters into a period of decline, which may last for some considerable time.

The fall of the Stalinist bureaucratic regime in the Soviet Union was the result of the fact that the bureaucracy was unable to maintain the kind of growth rates that the nationalized planned economy had achieved in the 1930s and which continued until about 1964. By the late 1970s the Soviet economy was not growing at all. That spelled doom for the Stalinist system. It should be added, though, that what has replaced it is even worse. The so-called market reform led to an unprecedented collapse of the productive forces of approximately 60 percent.

The present world situation suggests that the capitalist system is now reaching a similar impasse to the one reached earlier by Stalinism. On a world scale the economy is foundering, the stock markets have lost half of their value, unemployment is growing, there are numerous imbalances of debt left over from the earlier period of rapid growth. There is huge overproduction (“overcapacity”) expressed in large unsold inventories. Big companies are filing for bankruptcy. Even Ford Motors is technically bankrupt.

A Turning Point in History

To describe this situation as a “correction” is a misnomer. The present crisis has all the hallmarks of one of those major turning points in world history where quantity suddenly turns into quality, like a phase transition in physics. There are many symptoms that powerfully suggest this.

Everywhere we look fault lines are appearing — and not only in the economic field. The whole system is becoming turbulent. The most general feature is extreme instability at all levels: economic, financial, political, diplomatic and military. Wars and economic, political and diplomatic crises succeed each other with breathtaking speed.

In a matter of weeks, institutions that had lasted for over half a century, since the end of the Second World War, have been undermined and shattered like the rocks in an earthquake: the United Nations, NATO, the European Union, the Group of Eight have all been shaken to the core. America confronts its former allies in Europe and Turkey as enemies. These frictions in turn threaten to undermine the fragile structure of world trade.

Many blame the activities of the US President, George W. Bush. But Mr. Bush is only the unconscious agent of historical processes that he has inherited and the existence of which he does not suspect. Paradoxically, by acting in the way he has, he is hastening the demise of the socio-economic system he hopes to preserve. This is a very graphic example of the dialectic of history!

Many people are puzzled by the state of the world, which seems to have suddenly gone mad. But in fact, the present crisis can be explained in quite scientific terms. To do so, however, a knowledge of the Marxist method — of dialectical and historical materialism — is necessary.

To borrow the terminology of chaos theory, the global system of capitalism was poised on the edge of chaos. It has now “gone critical.” The old laws and rules no longer apply. The fault lines and fractures are multiplying out of control. The plans of governments, economists and US army generals give results that are diametrically opposite to what was intended. Chaos rules.

It is extremely difficult to predict the result of the present crisis with any accuracy. The shocks to the system are severe but can be detained before producing a total collapse. The main reason why the system can recover a degree of equilibrium is the absence of what Marxists call the subjective factor — the revolutionary party and the leadership.

This is the fundamental difference between history and the processes of nature: history requires the conscious activity of men and women. One might think that this would exclude any real similarity with the processes at work in inanimate nature, but this is not the case. The workings of human consciousness is also governed by the laws of dialectics. As Marx explains: *social being determines consciousness*.

The processes that shape the development of society impact in a decisive way on the thinking of men and women. In normal periods people accept uncritically the norms of the society in which they live: habit, routine, and tradition weigh heavily on human consciousness in such periods. It is the sociological equivalent of inertia in mechanics.

But in critical moments, the force of ancient tradition and the inertia of custom break down. People begin to question the morality, laws, traditions and customs of the society in which they have grown up. In such periods, the Biblical saying (also profoundly dialectical) comes into force: for the first shall be last and the last shall be first.

Marxism and the USA

Dialectically, things turn into their opposite. In the coming period there will be many surprises. The USA, the wealthiest and most powerful capitalist nation on earth seems to be the last candidate for the socialist revolution. But that is not necessarily the case. Once the powerful American working class gets on the move, the earth will tremble. Very quickly they can catch up and overtake their European brothers and sisters.

The American workers lack a party, but this fact also has advantages. They have not passed through the school of reformist politics. They will enter the arena of politics completely free from the bad habits of routine and conservatism that we suffer from in the European labor movement. They are fresh and will be open to the most radical ideas. All that is necessary is to start — and they will begin to move in the next period.

The old system of Republicrats and Democrans will break down. The workers will see the need for a new party — a party based on the unions, to represent the interests of Labor. Once this party is established it will move very quickly to radical socialist ideas. It will attract all that is living and vibrant in American society — and there is an abundance of such material! The youth, the

blacks, the Latinos, the women — all will flock to the banner of a mass American Labor Party.

What role will Marxism play in this process? The aroused American working class will look for ideas to guide its struggle. Only Marxism can give them what they are looking for. The old prejudices against socialism and Marxism will not last long in the new situation. The ideas of Marxism that are now known only to small groups of people will be listened to by millions. Of course, the Marxists will have to learn to speak “American”!

America now has the reputation of the most counter-revolutionary force on earth. But let us remind ourselves that before 1917 Tsarist Russia occupied the same position. Yet Russia produced the Bolshevik Party, Lenin and Trotsky. It is not at all excluded that the USA will produce equally great revolutionary figures.

If the present book plays a modest role in spreading and popularizing the ideas of Marxism in the United States, it will have been well worth the effort.

Alan Woods

London, April 4th 2003

PART THREE: LIFE, MIND AND MATTER

10. THE DIALECTICS OF GEOLOGY

There is an English saying, “as solid as the ground under our feet.” This comforting idea, however, is very far from the truth. The earth beneath our feet is not as solid as it seems. The rocks, the mountain ranges, the continents themselves, are in a continuous state of movement and change, the exact nature of which has only begun to be understood in the latter half of this century. Geology is the science which deals with the observation and explanation of all the phenomena that take place on and within the planet. Unlike other natural sciences such as physics and chemistry, geology bases itself, not on experiments, but on observation. As a result its development was heavily influenced by the way in which these observations were interpreted. These, in turn, were conditioned by the philosophical and religious trends of the day. This fact explains the tardy development of geology in relation to other earth-sciences. Not until 1830 did Charles Lyell, one of the fathers of modern geology, show that the earth is far older than the book of *Genesis* says. Later measurements based on radioactive decay confirmed this, establishing that the earth and the moon are approximately 4.6 billion years old.

From the earliest period, men and women were aware of phenomena like earthquakes and volcanic eruptions which revealed the tremendous forces lying pent up beneath the earth’s surface. But until the present century such phenomena were attributed to the intervention of the gods. Poseidon-Neptune was the “earth-shaker,” while Vulcan-Hephistes, the lame blacksmith of the gods, lived in the bowels of the earth, and caused volcanoes to erupt with his

hammer-blows. The early geologists of the 18th and 19th centuries were aristocrats and clergymen, who believed, with Bishop Ussher, that the world had been created by God on 23rd October 4004 B.C. In order to explain the irregularities of the earth's surface, such as canyons and high mountains, they developed a theory — catastrophism — which tried to make the observed facts fit in with the Biblical stories of cataclysms, like the Flood. Each catastrophe wiped out whole species, thus conveniently explaining the existence of the fossils which they found buried deep inside the rocks in coal mines.

It is no coincidence that the catastrophe theory of geology gained most ground in France, where the Great Revolution of 1789-94 had a decisive influence on the psychology of all classes, the echoes of which reverberated down the generations. For those inclined to forget, the revolutions of 1830, 1848, and 1870 provided a vivid reminder of Marx's penetrating observation that France was a country where the class struggle is always fought to the finish. For Georges Cuvier, the celebrated French naturalist and geologist of the 19th century, the earth's development is marked by a "a succession of brief periods of intense change and that each period marks a turning point in history. In between, there are long uneventful periods of stability. Like the French Revolution, after upheaval, everything is different. Likewise, geographical time is subdivided into distinct chapters, each with its own basic theme."¹

If France is the classical country of revolution and counter-revolution, England is the classical home of reformist gradualism. The English bourgeois revolution was, like the French, quite a bloody affair, in which a king lost his head, along with a lot of other people. The "respectable classes" in England have been trying hard to live this down ever since. They far prefer to dwell on the comically misnamed "Glorious Revolution" of 1688, an inglorious coup d'état in which a Dutch adventurer acted as the middleman in an unprincipled carve-up of power between the money-grubbing nouveaux-riches of the City and the aristocrats. This has provided the theoretical basis for the Anglo-Saxon tradition of gradualism and "compromises."

Aversion to revolutionary change in any shape or form is translated into an obsessive concern to eliminate all traces of sudden leaps in nature and society. Lyell put forward a diametrically opposite view to catastrophism. According to him, the boundary line between different geological layers represented not catastrophes but simply recorded the shifting pattern of transitions between two neighboring sedentary environments. There was no need to look for global

patterns. Geological periods were merely a convenient method of classification, rather like the divisions of English history according to reigning monarchs.

Engels paid tribute to Lyell's contribution to the science of geology:

"Lyell first brought sense into geology by substituting for the sudden revolutions due to the moods of the Creator the gradual effects of a slow transformation of the earth." However, he also recognizes his deficiencies: "The defect of Lyell's view — at least in its first form — lay in conceiving the forces at work on the earth as constant, both in quality and quantity. The cooling of the earth does not exist for him; the earth does not develop in a definite direction but merely changes in an inconsequent fortuitous manner." ²

"These views represent the dominant philosophies of the nature of geological history," writes Peter Westbroek, "— on the one hand catastrophism, the notion of stability interrupted by brief periods of rapid change, and on the other, gradualism, the idea of continuous fluctuation. In Coquand's time, catastrophism was generally accepted in France, but sympathy for this philosophy would soon fade, for purely practical reasons. Geological theory had to be built from scratch. The founders of geology were forced to apply the principle of the present as the key to the past as rigorously as possible. Catastrophism was of little use precisely because it claimed that the geological conditions were fundamentally different from those in the subsequent periods of stability. With the far more advanced geological theory now at our disposal, we can adopt a more flexible attitude. Interestingly, catastrophism is regaining momentum." ³

The argument between gradualism and catastrophism is really an artificial one. Hegel already dealt with this by inventing the nodal line of measurement, in which the slow accumulation of quantitative changes gives rise to periodic qualitative leaps. Gradualism is interrupted, until a new equilibrium is restored, but at a higher level than before. The process of geological change corresponds exactly to Hegel's model, and this has now been conclusively proved.

Wegener's Theory

At the beginning of the 20th century, Alfred Wegener, a German scientist, was struck by the similarity of the coast lines of eastern South America and the West Coast of Africa. In 1915, he published his theory of the transposition of continents, which was based on the assumption that, sometime in the past, all the continents had been part of a single great land-mass (Pangaea), which later

broke up into separate land-masses which drifted apart, eventually forming the present continents. Wegener's theory inevitably failed to give a scientific explanation of the mechanism behind continental drift. Nevertheless, it constituted a veritable revolution in geology. Yet it was indignantly rejected by the conservative geological community. The geologist Chester Longwell even went so far as to say that the fact that the continents fitted together so well was "a trick of the devil" to deceive us. For the next 60 years, the development of geology was hampered by the dominant theory of "isostasy," a steady state theory which only accepted vertical movements of the continents. Even on the basis of this false hypothesis major steps forward were made, preparing the ground for the negation of the theory which increasingly entered into conflict with the observed results.

As so often happens in the history of science, technological advance linked to the requirements of production, provided the necessary stimulus for the development of ideas. The search for oil by big companies like Exxon led to major innovations for the investigation of the geology of the sea-bed, and the development of powerful new methods of seismic profiling, deep-sea drilling and improved methods for dating fossils. In the mid-1960s, Peter Vail, a scientist in Exxon's main Houston laboratory, began to study the irregularities in the linear patterns on the ocean floor. Vail was sympathetic to the old French view of interrupted evolution, and believed that these breaks in the process represented major geological turning-points. His observations revealed patterns of sedimentary change which seemed to be the same all over the world. This was powerful evidence in favor of a dialectical interpretation of the geological process.

Vail's hypothesis was greeted with skepticism by colleagues. Jan van Hinte, another of Exxon's scientists, recalled: "We paleontologists didn't believe a word he was saying. We were all brought up in the Anglo-Saxon tradition of gradual change, and this smelled of catastrophism." However, Jan van Hinte's own observations of the fossil and seismic record in the Mediterranean, revealed exactly the same as Vail's, and the ages of the rock corresponded to Vail's predictions. The picture that now emerges is clearly dialectical:

"It is a common feature in nature: the drop that makes the bucket overflow. A system that is internally stabilized is gradually undermined by some external influence until it collapses. A small impetus then leads to dramatic change, and an entirely new situation is created. When the sea level is rising, the sediments build up gradually on the continental shelf. When the sea goes down, the

sequence becomes destabilized. It hangs on for some time, and then — Wham! Part of it slides into the deep sea. Eventually, sea levels begin to rise and bit by bit, the sediment builds up.”⁴

Quantity changed into quality when in the late 1960s, as a result of deep-sea drilling on the ocean floor, it was discovered that the sea-bed of the Atlantic Ocean was moving apart. The “Mid-Ocean Ridge” (that is, an under-sea mountain chain located in the Atlantic) indicated that the American continent is moving away from the Euro-Asian land-mass. This was the starting-point for the development of a new theory, that of plate-tectonics, which has revolutionized the science of geology.

Here we have a further example of the dialectical law of the negation of the negation, as applied to the history of science. Wegener’s original theory of continental drift is negated by the steady state theory of isostasy. This in turn is negated by plate tectonics, which marks a return to the older theory but on a qualitatively higher level. Wegener’s theory was a brilliant and basically correct hypothesis, but he was unable to explain the exact mechanism whereby continental drift occurs. Now, on the basis of all the discoveries and scientific achievements of the past half-century, we not only know that continental drift is a fact, but we can explain exactly how it takes place. The new theory is on a far higher level than its predecessor, with a deeper understanding of the complex mechanisms through which the planet evolves.

This represents the equivalent in geology of the Darwinian revolution in biology. Evolution applies not only to animate but also to inanimate matter. Indeed, the two interpenetrate and condition each other. Complex natural processes interconnect. Organic matter — life — arises inevitably from inorganic matter at a certain point. But the existence of organic matter in turn exercises a profound effect upon the physical environment. For example, the existence of plants producing oxygen had a decisive effect on the atmosphere and therefore on climatological conditions. The development of the planet and of life on earth provide a wealth of examples of the dialectics of nature, development through contradictions and leaps, long periods of slow “molecular” change alternate with catastrophic developments, from the collision of continents to the sudden extinction of whole species. Moreover, closer examination reveals that the sudden, apparently inexplicable leaps and catastrophes normally have their roots in the earlier periods of slow, gradual change.

What are Plate Tectonics?

The earth's molten surface eventually cooled down sufficiently to form a crust, under which gas and molten rock were trapped. The surface of the planet was continually broken up by exploding volcanoes, spewing out lava pools. Gradually a thicker crust was formed, entirely made up of volcanic rock. At that time, the first small continents were formed out of the sea of molten rock (magma), and the oceanic crust began to form. Gases and steam from volcanic eruptions began to thin out the atmosphere, causing violent electrical storms. Owing to the higher thermal regime, this was a period of tremendous catastrophes, explosions, with the continental crust forming then being blown apart, then forming again, partial melting, crystal formation and collisions, on a far vaster scale than anything seen since. The first micro-continents moved far faster and collided more frequently than today. There was a rapid process of generation and recycling of the continental crust. The formation of the continental crust was the most fundamental event in the history of the planet. Unlike the sea-bed, the continental crust is not destroyed by subduction into the mantle, but increases its total volume in the course of time. The creation of the continents was thus an irreversible event.

The earth is made up of a number of layers of material. The main layers are the core (divided into the inner and outer core), the thick mantle, and the thin crust on the surface. Each layer has its own chemical composition and physical properties. As the molten earth cooled some 4 billion years ago, the heavier materials sank to the earth's center, while the lighter elements stayed nearer the surface. The earth's inner core is a solid mass, compressed by colossal pressures. The crust forms a thin layer around the semi-liquid mantle, like the skin around an apple. From the cool thin crust, down 50 kilometers, the temperature is about 800°C. Deeper still, at around 2,000 km, the temperature rises to well over 2,200°C. At this depth the rocks behave more like liquids.

This crust supports the oceans and land masses, as well as all forms of life. About seven-tenths of the crust is covered by water, which is a fundamental feature of the planet. The surface crust is very uneven, containing huge mountain ranges on its land mass, and under water ranges in the deep oceans. An example of one is the Mid-Atlantic Ridge, which forms the boundary between four of the earth's plates. The crust is made up of ten major plates which fit together like a jigsaw puzzle. However, along the edges of these plates "faults" are situated,

where volcanic activity and earthquakes are concentrated. The continents are fixed into these plates and move as the plates themselves move.

At the border of these plates underwater volcanoes spew out molten rock from the bowels of the earth, creating new ocean floor. The sea bed spreads away from the ridge like a conveyer belt, carrying with it huge rafts of continental crust. Volcanoes are the source of the transformation of enormous energy from the earth into heat. There are an estimated 430 active volcanoes at present. Paradoxically, volcanic explosions releases energies that cause the rocks at the crust to melt. The earth's crust (lithosphere) is being continually changed and renewed. New lithosphere is constantly being created by the intrusion and extrusion of magma at the mid-ocean ridges through the partial melting of the mantle (asthenosphere). This creation of new crust at these faults pushes the old floor apart and with it the continental plates. This new lithosphere spreads away from the mid-ocean ridges as more material is added, and eventually, the very expansion of the ocean floor leads elsewhere to it submerging into the earth's interior.

This process explains the movement of continents. The constant subterranean turmoil in turn creates colossal heat, which builds up and produces new volcanic activity. These areas are marked by island arcs and mountain ranges and by volcanoes, earthquakes and deep ocean trenches. This keeps the balance between new and old, in a dialectical unity of opposites. As the plates themselves collide, they produce earthquakes.

This continuous activity under the earth's surface governs many phenomena affecting the development of the planet. The land mass, oceans and atmosphere are not only affected by the sun's rays, but also by gravity and the magnetic field surrounding the earth. "Continual change," says Engels, "i.e., abolition of abstract identity with itself, is also found in so-called inorganic things. Geology is its history. On the surface, mechanical changes (denudation, frost), chemical changes (weathering), and, internally, mechanical changes (pressure), heat (volcanic), chemical (water, acids, binding substances), in great upheaval, earthquakes, etc." Again, "Every body is continually exposed to mechanical, physical. and chemical influences, which are always changing it and modifying its identity." ⁵

Under the Atlantic Ocean there is an undersea volcanic mountain chain where new magma is constantly being created. As a result, the oceanic crust is being enlarged, and is pushing apart the continents of South America and Africa, and also North America and Europe. However, if some areas are getting bigger,

others must also be consumed. As the American continent is being pushed by colossal forces against the Pacific Ocean crust, the ocean plate is being forced to dip under America, where it dissolves, moves in currents, and eventually emerges — after millions of years — in another mid-ocean ridge. These are not smooth, linear processes, but take place through contradictions and leaps of truly cataclysmic dimensions. There are times when the forces beneath the earth's outer crust meet with such resistance that they are forced to turn back upon themselves, and find some new direction. Thus, for a very long period, an ocean like the Pacific can be enlarged. However, when the balance of forces changes, the whole process goes into reverse. A vast ocean can be squeezed between two continents, and eventually disappear, forced between and under the continents. Such processes have occurred many times in the history of the planet over 4,600 million years. 200 million years ago, there was an ocean — Iethys — between Euro-Asia and Africa. Today the only remnant of that ocean is part of the Mediterranean sea. The rest of that great ocean has been consumed and has vanished beneath the Carpathian Mountains and the Himalayas, destroyed by the collision of India and Arabia with Asia.

On the other hand, when a mid-ocean ridge is closed (that is, consumed under a continent) then new lithosphere will appear in another place. As a rule, the lithosphere breaks through at the weakest point. Unimaginable forces accumulate over millions of years, until eventually quantitative change produces a cataclysm. The outer shell is shattered, and the new lithosphere breaks through, opening up the way for the birth of new oceans. In the present day, we can see signs of this process in the volcanic valley of Afar in East Africa, where the continent is breaking up and a new ocean will be created in the next fifty million years. In effect, the Red Sea represents the every early stages in the development of an ocean separating South Arabia from Africa.

The understanding that the earth is not a static but dynamic entity gave a powerful impulse to geology, placing it on a really scientific basis. The great success of the plate tectonics theory is that it dialectically combines all the natural phenomena, overturning the conservative conceptions of the scientific orthodoxy based upon formal logic. Its basic idea is that everything upon earth is in constant movement, and that this takes place through explosive contradictions. Oceans and continents, mountains and basins, rivers, lakes and coastlines are in a process of constant change, in which periods of “calm” and “stability” are violently interrupted by revolutions on a continental scale. Atmosphere, climatic conditions, magnetism, even the location of magnetic

poles of the planet are likewise in a permanent state of flux. The development of each individual process is influenced and determined, to one extent or another, by the interconnection with all the other processes. It is impossible to study one geological process in isolation from the rest. All of them combine to create a unique sum total of phenomena which is our world. Modern geologists are compelled to think in a dialectical way although they have never read a single line of Marx and Engels, just because their subject-matter can be adequately interpreted in no other way.

Earthquakes and the Genesis of Mountains

As a young man, Charles Darwin found the fossil of a marine animal far inland. If it were true that marine animals had once lived in this place, then the existing theories of the earth's history were wrong. Darwin showed his find excitedly to an eminent geologist, who replied: "Oh, let's hope it's not true." The geologist preferred to believe that someone had dropped the fossil there, after a trip to the sea-side! From the standpoint of common sense, it appears incredible that continents should move. Our eyes tell us that this is not so. The average velocity for that kind of movement is around 1-2 centimeters a year. Therefore, for normal purposes it may be discounted. However, over a much longer period of millions of years, these slight changes produce the most dramatic changes imaginable.

On the top of the Himalayas (around 8,000 meters above sea level) there are rocks which contain fossils from marine organisms. This means that these rocks which originated at the bottom of a prehistoric sea, the Tethys ocean, were thrust upwards over a period of 200 million years to create the highest mountains in the world. Even this process was not a uniform one, but involved contradictions, with tremendous upheavals, advances and retreats, through thousands of earthquakes, massive destruction, breaks in continuity, deformations and folds. It is evident that the movement of the plates is caused by gigantic forces inside the earth. The entire make-up of the planet, its appearance and identity is determined by this. Humanity has direct experience of only a tiny fraction of these forces through earthquakes and volcanic eruptions. One of the basic features of the earth's surface are the mountain ranges. How do these develop?

Take a bunch of paper sheets and press it against a wall. The sheets will fold and deform under the pressure and they will "move" upwards, creating a curved feature. Now imagine the same process when an ocean is being

pressurized between two continents. The ocean is being forced under one of the continents, but the rocks at that point will be deformed and fold, creating a mountain. After the total disappearance of the ocean, the two continents will collide, and the crust at that point will be thickened vertically as the continental masses are compressed. The resistance to subduction causes large nappe folds and thrust faults, and this uplift gives rise to a mountain chain. The collision between the Euro-Asian and the African plates (or parts of Africa) created a long mountain chain, starting from the Pyrenees in the West, passing through the Alps (collision of Italy and Europe), the Balkans, Hellenic, Tauridic, Caucasus (collision of South Arabia and Asia) and finally the Himalayas (collision of India and Asia). In the same manner, the Andes and Rocky mountains in America are located over the zone where the Pacific ocean plate is dipping under the American continent.

It is not surprising that these zones are also characterized by intense seismic activity. The world's seismically active zones are exactly the borders between the different tectonic plates. In particular, zones where mountains are being created signify areas where colossal forces have been accumulated over a long time. When continents collide, we see the accumulation of forces acting on different rocks, at different locations and in different ways. Those rocks which are composed of the hardest material resist deformation. But, at a critical point, quantity is transformed into quality, and even the hardest rocks are broken or plastically deformed. This qualitative leap is expressed in earthquakes, which despite the spectacular appearance, actually represent only a tiny movement of the earth's crust. The formation of a mountain chain requires thousands of earthquakes, leading to extensive folding, deformation and the movement upwards of rock.

Here we have the dialectical process of evolution through leaps and contradictions. The rocks which are being compressed present an initial barrier, offering resistance to the pressure of subterranean forces. However, when they are broken, they turn into their exact opposite, becoming channels for the release of these forces. The forces which operate under the surface are responsible for creating mountain chains and ocean trenches. But on the surface there are other forces which are operating in the opposite direction.

Mountains do not continuously rise higher and higher, because they are subject to opposing forces. On the surface we have weathering, erosion and transportation of matter from the mountains and the continents back to the oceans. Solid rocks are worn away by the action of strong winds, intense rain,

snow and ice, which weaken the outer shell of the rocks. After a period, there is a further qualitative leap. The rocks gradually lose their consistency, small grains begin to separate from them. The effect of wind and water, especially rivers, transport millions of grains from higher levels to basins, lakes, but mainly oceans, where these rock-particles are gathered together again at the bottom of the sea. There they are buried again, as more and more material is accumulating above them and a new operation appears, the opposite one — rocks are being consolidated again. As a result, new rocks are created, which will follow the movement of the ocean bed until they are once again buried under a continent, where they will melt, possibly emerging once again at the top of a new mountain somewhere in the earth's surface.

Subterranean Processes

The fact that the material under the solid surface is liquid is shown by the lava flows from volcanoes. Rocks are buried very deep in the earth's crust under big mountains and in subduction zones. Under such conditions they suffer a number of changes. As they sink deeper into the crust, the earth's internal activity leads to a rise in temperature. At the same time, the weight of the overlying rocks and mountains leads to a further tremendous increase in pressure. Matter is organized in specific combinations of elements which in the solid state form crystals called minerals. Different minerals come together to form rocks. Every rock has a combination of minerals, and every mineral has a unique combination of elements in a specific crystal form. The changes in temperature and pressure cause changes in the chemistry of most minerals through the substitution of one element for another. While some minerals, within certain limits, remain stable, at a critical point, matter is reorganized in different crystal forms. This causes a qualitative change in the minerals, which react, producing a new combination which reflects the new conditions. This is a qualitative leap, like the change of water to ice at 0°C. The result is that the entire rock is transformed into a new rock. Thus, under the pressure of environmental conditions, we have a sudden leap, involving a metamorphosis not only of minerals but of the rocks themselves. There is no one single mineral form which remains stable under all natural conditions.

In zones which experience the subduction of an ocean under a continent, rocks can be buried very deep in the crust. Under such extreme conditions, the rocks themselves begin to melt. However, this process does not happen all at

once. We have the phenomenon of partial melting, because different minerals melt at different points. The melting material has a tendency to move upwards, since it is less dense than the surrounding rocks. But this movement is not without problems, owing to the resistance of the overlying rocks. The molten rock, or magma, will slowly move upwards until, faced with a solid barrier, it is temporarily forced to halt. In addition, the outer area of the magma will start to cool and consolidate into a solid layer which will act as an additional barrier in the path of the magma. But eventually, the elemental force of pressure from below gradually increases to a point where the barriers are broken, and the magma finally breaks through to the surface in a violent explosion, realizing colossal pent-up forces.

It is therefore evident that these processes do not take place in an accidental way, as it may appear to the unfortunate victims of an earthquake, but correspond to fundamental laws, which we are now only beginning to understand. They take place in specific zones, located at the borders of the plates, especially in mid-ocean ridges and behind subduction zones. This is exactly the reason why there are active volcanoes in Southern Europe (Santorini in Greece, Etna in Italy), in Japan, where there are subduction zones (which led to the Kobe earthquake), in mid-Atlantic and the Pacific Ocean (volcanic islands and submerged volcanoes in mid-ocean ridges) and in East Africa (Kilimanjaro) where there is a continental drift and the creation of a new ocean.

It is well known to miners that the temperature of the earth's crust increases the further down you go. The main source of this immense heat, which is responsible for all the processes that take place in the bowels of the earth, is heat energy released by the decay of radioactive elements. Elements contain isotopes (atoms of the same element, but with different mass), some of which are radioactive — that is to say, they are unstable and break down with time — producing more heat and more stable isotopes. This continuous process of reaction is proceeding very slowly. Because these isotopes have been decaying since the origin of the earth, when they must have been more abundant. Thus, heat production and heat flow must have been higher than at present, maybe two or three times more during the Archaean period than now.

The Archaean-Proterozoic boundary is likewise of major significance, representing a qualitative leap. Not only do we have the emergence of the first life-forms, but also another crucial change in the land mass — from many small continental plates in the Archaean, with its numerous plate collisions, to the formation of larger, thicker and more stable plates during the Proterozoic. These

large continental masses were the result of the aggregation of many small proto-continental plates. This was the period of major mountain-building, of which two major episodes can be distinguished — 1.8 billion and 1 billion years ago. The remnant of the last event of this titanic process, in which the rocks were repeatedly metamorphosed, deformed and re-shaped, can be seen today in south Canada and northeast Norway.

The gradualist theory of uniformitarianism, originally advanced by Hutton in 1778, has no application whatsoever to the early history of the earth. All the available evidence suggests that modern-style plate tectonics began in the early Proterozoic, whilst some earlier variant of the plate tectonic process seems most likely to have been in operation in Archaean times. More than 80% of the present continental crust was created before the end of the Proterozoic period. Plate tectonics is the determining factor in all these processes. Mountain building, earthquakes, volcanoes and metamorphosis are all interconnecting processes, one depends on the other, each determines, influences, causes or is caused by the other, and all of them, taken together, constitute the evolution of the earth.

II. HOW LIFE AROSE

Oparin and Engels

“What we do not know today we shall know tomorrow.” This simple statement underlies the conclusion of a scientific paper on the Origin of Life written by the Russian biologist Aleksandr Ivanovich Oparin in 1924. It was the first time that a modern appreciation of the subject had been undertaken, and opened up a new chapter in the understanding of life. It was no accident that as a materialist and dialectician, Oparin approached this subject from an original perspective. This was a bold beginning, at the very dawn of biochemistry and molecular biology, and was backed up independently by the contribution of British biologist J. B. S. Haldane — again a materialist — in 1929. This work produced the Oparin-Haldane hypothesis, on which the subsequent understanding of the origin of life is based. “In it,” writes Asimov, “the problems of life’s origin for the first time was dealt with in detail from a completely materialistic point of view. Since the Soviet Union is not inhibited by the religious scruples to which the Western nations feel bound, this, perhaps, is not surprising.”⁶

Oparin always acknowledged his debt to Engels, and made no secret of his philosophical position. Oparin writes:

This problem (of life's origins) has however always been the focus of a bitter conflict of ideas between two irreconcilable schools of philosophy — the conflict between idealism and materialism.

A completely different prospect opens out before us if we try to approach a solution of the problem dialectically rather than metaphysically, on the basis of a study of the successive changes in matter which preceded the appearance of life and led to its emergence. Matter never remains at rest, it is constantly moving and developing and in this development it changes over from one form of motion to another and yet another, each more complicated and harmonious than the last. Life thus appears as a particular very complicated form of the motion of matter, arising as a new property at a definite stage in the general development of matter.

As early as the end of the last century Frederick Engels indicated that a study of the history of the development of matter is by far the most hopeful line of approach to a solution of the problem of the origin of life. These ideas of Engels were not, however, reflected to a sufficient extent in the scientific thought of his time.

Engels was essentially correct when he described life as the mode of motion of proteins. However, today we can add that life is the function of the mutual reactions of nucleic acids and of proteins. As Oparin explained:

F. Engels, in common with biologists of his time, often used the terms 'protoplasm' and "albuminous bodies." The "proteins" of Engels must therefore not be identified with the chemically distinct substances which we have now gradually succeeded in isolating from living things, nor with purified protein preparations composed of mixtures of pure proteins. Nevertheless Engels was considerably in advance of the ideas of his time when, in speaking of proteins, he specially stressed the chemical aspects of the matter and emphasized the significance of proteins in metabolism, that form of the motion of matter which is characteristic of life.

It is only now that we have begun to be able to appreciate the value of the remarkable scientific perspicacity of Engels. The advances in protein chemistry now going on enabled us to characterize proteins as individual chemical compounds, as polymers of amino acids having extremely specific structures."⁷

J. D. Bernal offers an alternative to Engels' definition of life as "a partial, continuous, progressive, multiform and conditionally interactive, self-realization of the potentialities of atomic electron states."⁸

Although the Oparin-Haldane hypothesis laid the basis for a study of life origins, as a branch of science it is more correct to ascribe it to the revolution in biology in the mid-20th century. Theories concerning the origin of life are largely speculative. There are no traces in the fossil record. We are dealing here with the simplest and most basic life-forms imaginable, transitional forms which were quite unlike the idea of living things we have today, but which nevertheless represented the decisive leap from inorganic to organic matter. Perhaps, as

Bernal comments, it is more correct to say the origin not of life, but the origin of the processes of life.

Engels explains that the Darwinian revolution “reduced the gulf between inorganic and organic nature to a minimum but removed one of the most essential difficulties that had previously stood in the way of the theory of descent of organisms. The new conception of nature was complete in its main features; all rigidity was dissolved, all fixity dissipated, all particularity that had been regarded as eternal became transient, the whole of nature shown as moving in eternal flux and cyclical course.”⁹ The scientific discoveries since this was written have served to strengthen this revolutionary doctrine.

Oparin drew the conclusion that the original atmosphere of the earth was radically different from that of today. He suggested that instead of oxygen, the character of the atmosphere was reducing rather than oxidizing. Oparin proposed that the organic chemicals on which life depends formed spontaneously in such an atmosphere under the influence of ultra violet radiation from the sun. Similar conclusions were arrived at independently by J. B. S. Haldane:

The Sun was perhaps slightly brighter than now and as there was no oxygen in the atmosphere the chemically active ultra-violet rays from the Sun were not, as they now are, mainly stopped by ozone (a modified form of oxygen) in the upper atmosphere, and oxygen itself lower down. They penetrated to the surface of the land and sea, or at least to the clouds. Now, when ultra-violet acts on a mixture of water, carbon dioxide, and ammonia, a vast variety of organic substances are made, including sugars and apparently some of the materials from which proteins are built up.¹⁰

In a more generalized form Engels pointed in the right direction fifty years previously: “If, finally, the temperature becomes so far equalized that over a considerable portion of the surface at least it does not exceed the limits within which protein is capable of life, then, if other chemical conditions are favorable, living protoplasm is formed.” He continued, “Thousands of years may have passed before the conditions arose in which the next advance could take place and this formless protein produce the first cell by formation of nucleus and cell membrane. But this first cell also provided the foundation for the morphological development of the whole organic world; the first to develop, as it is permissible to assume from the whole analogy of the palaeontological record, were innumerable species of non-cellular and cellular protista...”¹¹ Although this process took place over a far longer time-span, this is a generally correct prognosis.

Just as Engels' ideas were ignored at the time by the scientific community, so were those of Oparin and Haldane. Only recently are these theories getting the recognition they deserve. Richard Dickerson writes:

Haldane's ideas appeared in *Rationalist Annual* in 1929, but they elicited almost no reaction. Five years earlier Oparin had published a small monograph proposing rather similar ideas about the origin of life, to equally little effect. Orthodox biochemists were too convinced that Louis Pasteur had disproved spontaneous generation once and for all to consider the origin of life a legitimate scientific question. They failed to appreciate that Haldane and Oparin were proposing something very special: not that life evolves from non-living matter today (the classical theory of spontaneous generation, which was untenable after Pasteur) but rather that life once evolved from non-living matter under the conditions prevailing on the primitive earth and in the absence of competition from other living organisms.¹²

How Did Life Arise?

There is no subject of such tremendous import for us as the question of how living, feeling, thinking creatures arose out of inorganic matter. This riddle has occupied the human mind from the earliest times, and has been answered in various ways. We can broadly identify three trends:

1st theory – God created all life, including humans.

2nd theory – life arose from inorganic matter, by spontaneous generation, as maggots from decaying flesh, or beetles from a dunghill (Aristotle).

3rd theory – life came from outer space in a meteorite, which fell on the earth, and then developed.

This transformation from inorganic to organic is a comparatively recent view. In contrast, the theory of spontaneous generation — that life originated from nothing — has a long history. From ancient Egypt, China, India and Babylon came the belief in spontaneous generation. It is contained in the writing of the ancient Greeks. "Here maggots arise from dung and rotting meat, here lice form themselves from human sweat, here fireflies are born from the sparks of a funeral pyre, and finally, frogs and mice originate from dew and damp earth...For them spontaneous generation was simply an obvious, empirically established fact the theoretical basis of which was of secondary importance," states Oparin.¹³ Much of this was bound up with religious legends and myths. By contrast, the approach of the early Greek philosophers was materialist in character.

It was the idealist view of Plato (expressed also by Aristotle), that invested spontaneous generation with a supernatural quality and later formed the basis of

mediaeval scientific culture and dominated people's minds for centuries. Matter does not contain life but is infused with it. Through Greek and Roman philosophical schools, it was borrowed and elaborated by the early Christian church to develop their mystical conception of the origin of life. St. Augustine saw in spontaneous generation a manifestation of divine will — the animation of inert matter by the “life-creating spirit.” As Lenin points out, the scholastics and clerics seized upon that which was dead in Aristotle and not upon that which was alive. It was later developed by Thomas Aquinas in according with the teachings of the Catholic church. A similar standpoint is held by the Eastern churches. The Bishop of Rostov, Dimitrii, in 1708 explained that Noah did not take in his ark those animals capable of spontaneous generation: “These all perished in the Flood and after the Flood they arose anew from such beginnings.” This was the dominant belief in Western society up until the mid-19th century.

The great T. H. Huxley in his Edinburgh lecture in 1868 first clearly explained that life had one common physical basis: protoplasm. He stressed it was functionally, formally and substantially the same over the whole range of living things. In function, all organisms reveal movement, growth, metabolism and reproduction. In their form they are composed of nucleated cells; and in substance, they are all made up of proteins, a chemical compound of carbon, hydrogen, oxygen and nitrogen. This graphically reveals the underlying unity of life.

The French scientist Louis Pasteur, the father of microbiology, in a series of experiments finally discredited the theory of spontaneous generation. “Life could only come from life,” said Pasteur. The discoveries of Pasteur dealt a crushing blow to the orthodox conception of spontaneous generation. The further triumph of Darwin's theory of evolution forced the vitalists (the idea of the “life force”) to look at the origin of life in a new way. From now on their defense of idealism came in the argument of the impossibility of understanding this phenomenon on the basis of materialism.

As early as 1907, in a book called *Worlds in the Making*, the Swedish chemist Svente Arrhenius put forward the theory of panspermia, which concluded that if life could not occur spontaneously on the earth, then it must have been introduced from other planets. He described spores traveling through space to “seed” life in other planets. Any life spores entering our atmosphere, as with meteorites, would burn up. To counter these criticisms, Arrhenius argued that life was therefore eternal, and had no origin. But the evidence contradicted his theory. It was shown that the existence of ultra-violet rays in space would

quickly destroy any bacterial spores. For example, microorganisms selected for their toughness were put on the space-capsule Gemini 9 in 1966, and exposed to radiation from space. They lasted six hours. More recently, Fred Hoyle thought that life had been brought to earth in the tails of comets. This idea has been revamped by Francis Crick and Leslie Orgel who suggested that earth may have been deliberately seeded by intelligent life from outer space! But such theories really solve nothing. Even if we accept that life came to earth from another planet, that still does not answer the question of how life arises, but merely puts it back another stage — to the hypothetical planet of origin.

It is not necessary to travel to outer space for a rational explanation of the origins of life. The origins of life can be found in the processes at work in nature on our own planet over three and a half billion years ago, under very special conditions. This process can no longer be repeated, because any such organisms would be at the mercy of existing life-forms which would make short work of them. It could only arise on a planet where no life existed, and also when there was little oxygen, since oxygen would combine with the chemicals needed to form life and break them down. The earth's atmosphere at that time was mainly made up of methane, ammonia and water vapor. Experiments in laboratories have shown that a mixture of water, ammonia, methane and hydrogen, subject to ultra violet radiation produced two simple amino acids, and traces of more complicated ones. In the late 1960s, complex molecules were found to be present in gas clouds in space. It is therefore possible that, even at a very early stage in the earth's formation, the elements for the emergence of life, or near-life, were already present in the form of amino-acids. More recent experiments have proven beyond all doubt that the proteins and nucleic acids which are the basis of all life could have emerged from the normal chemical and physical changes taking place in the primordial "soup."

According to Bernal, the unity of life is part of the history of life and, consequently, is involved in its origin. All biological phenomena are born, develop and die in accordance with physical laws. Biochemistry has demonstrated that all life on earth was the same at a chemical level. Despite the enormous variation between species, the basic mechanism of enzymes, coenzymes, and nucleic acids appear everywhere. At the same time, it forms a set of identical particles which hold themselves together by the principles of self-assembly in the most elaborate structures.

The Revolutionary Birth of Life

It is now becoming clear that the earth in its early stages did not function in the same manner as today. Atmospheric composition, climate, and life itself, developed through a process of convulsive changes, involving sudden leaps, and all kinds of transformations, including retrogressions. Far from being a straight line, the evolution of the earth and of life itself is full of contradictions. The first period of the earth's history, known as Archaean, lasted until 1.8 billion years ago. In the beginning, the atmosphere consisted mainly of carbon dioxide, ammonia, water and nitrogen, but there was no free oxygen. Before this point, the earth was lifeless. So how did life arise?

As we have seen, up to the beginning of the 20th century, geologists believed that the earth had a very limited history. Only gradually did it become clear that the planet had a far older history, and moreover, one that was characterized by constant and sometimes cataclysmic change. We see a similar phenomenon in relation to the supposed age of the solar system, which turns out to be considerably older than what was previously believed. Suffice to say that the advances of technology after the Second World War, especially the discovery of nuclear clocks, provided the basis for far more accurate measurements, which gave rise to a giant leap forward in our understanding of the evolution of our planet.

Today we can say that the earth became a solid planet more than 4.5 billion years ago. For everyday thinking, this seems an unimaginably long time. Yet, when dealing with geological time, we enter an entirely different order of magnitudes. Geologists are accustomed to dealing with millions and billions of years, as we think of hours, days and weeks. It became necessary to create a different time-scale, capable of embracing such periods of time. This closes the "early" stages of the earth's history, and yet this convulsive period accounts for no less than 88% of the total history of the planet. Compared to this, the entire history of the human race so far is no more than a fleeting moment. Unfortunately, the paucity of evidence from this period prevents us from obtaining a more detailed picture of the processes.

To understand the origin of life, it is necessary to know the composition of the earth's early environment and atmosphere. Given the likely scenario that the planet was formed from a dust cloud, its composition would have been largely hydrogen and helium. Today the earth contains large amounts of heavier elements, like oxygen and iron. In fact, it contains roughly 80% of nitrogen and

roughly 20% of oxygen. The reason for this is that the lighter hydrogen and helium escaped from the earth's atmosphere as the gravitational pull was insufficient to hold them. The larger planets with greater gravitation, like Jupiter and Saturn, have retained their dense atmosphere of hydrogen and helium. By contrast, our much smaller moon, with its low gravity, has lost all its atmosphere.

The volcanic gases which formed the primitive atmosphere must have contained water, along with methane and ammonia. We presume these were released from the interior of the earth. This served to saturate the atmosphere and produce rain. With the cooling of the earth's surface, lakes and seas began to form. It is believed that these seas constituted a pre-biotic (pre-life) "soup," where the chemical elements present, under the impact of ultra-violet light from the sun, synthesized to produce complex nitrogenous organic compounds, such as amino acids. This effect of ultraviolet was made possible by the absence of ozone in the atmosphere. This constitutes the basis of the Oparin-Haldane hypothesis.

All life is organized into cells, except for viruses. Even the simplest cell is an extremely complex phenomenon. The standard theory is that the heat from the earth itself would have been sufficient for complex compounds to form out of simple ones. The early life forms were able to store energy derived from the ultra violet radiation from the sun. However, changes in the composition of the atmosphere cut off the supply of ultra violet rays. Certain aggregates, which had developed the substance known as chlorophyll, were able to make use of the visible light that penetrated the ozone layer that filtered out the ultra violet. These primitive algae consumed carbon dioxide and emitted oxygen, leading to the creation of the present atmosphere.

Throughout the whole course of geological time, we can observe the dialectical interdependence of atmospheric and biospheric activity. On the one hand, most of the free oxygen in the atmosphere resulted from biological activity (through the process of photosynthesis in plants). On the other hand, changes in the composition of the atmosphere, in particular the increase in the amounts of molecular oxygen present, triggered off major biological innovations, which enabled new forms of life to emerge and diversify.

How did the first living cell arise out of the primordial soup of amino-acids and other simple molecules some four billion years ago? The standard theory, as expressed in 1953 by the Nobel prize winning chemist Harold Urey and his student Stanley Miller, was that life arose spontaneously in an early atmosphere

of methane, ammonia, and other chemicals, activated by lightning. Further chemical reactions would permit the simple compounds of life to develop into increasingly complex molecules, eventually producing the DNA double helix, or the single stranded RNA, both of which possess the power of reproduction.

The odds against this occurring by accident are truly staggering, as the Creationists love to point out. If the origin of life were a truly random event, then the Creationists would have a powerful case. It would really be a miracle! The basic structures of life and genetic activity in general depend upon incredibly complex and sophisticated molecules — DNA and RNA. In order to make a single protein molecule it would be necessary to combine several hundred amino-acid building blocks in a precise order. This is a formidable task, even in a laboratory with the latest equipment. The odds against such a thing occurring by accident in some warm little pool would be astronomical.

This question has recently been approached from the point of view of complexity, an offshoot of chaos theory. Stuart Kauffman, in his work on genetics and complexity, raised the possibility that a kind of life arose as a result of the spontaneous emergence of order out of molecular chaos, through the natural workings of the laws of physics and chemistry. If the primordial soup was sufficiently rich in amino-acids, it would not be necessary to wait for random reactions. A coherent, self-reinforcing web of reactions could be formed out of the compounds in the soup.

By means of catalysts different molecules could interact and fuse with each other to form what Kauffman calls an “autocatalytic set.” In this way, order emerging from molecular chaos would manifest itself as a system that grows. This is not yet life as we know it today. It would have no DNA, no genetic code, and no cell membrane. Yet it would exhibit certain lifelike properties. For instance it could grow. It would possess a kind of metabolism — absorbing in a steady supply of “food” molecules in the form of amino-acids and other simple compounds, adding them to itself. It would even have a primitive kind of reproduction, extending itself to spread over a wider area. This idea, which represents a qualitative leap, or “phase transition” in the language of complexity would mean that life had not arisen as a random event, but as a result of the inherent tendency of nature towards organization.

The first animal organisms were cells able to absorb the energy built up by the plant cells. The changed atmosphere, the disappearance of ultra violet radiation, and the presence of already existing life-forms rules out the creation of new life at the present time, unless it is achieved by artificial means under

laboratory conditions. In the absence of any rivals or predators in the oceans, the earliest compounds would have spread rapidly. At a certain stage, there would be the qualitative leap with the formation of a nucleic acid molecule capable of reproducing itself: a living organism. In this way, organic matter arises out of inorganic matter. Life itself is the product of inorganic matter organized in a certain way. Gradually, over a long period of million of years, mutation would begin to appear, eventually giving rise to new forms of life.

Thus we can arrive at a minimum age for life on earth. One of the main obstacles to the evolution of life as we know it was the absence of an ozone screen in the upper atmosphere in Archaean times. This allowed the penetration of the surface layers of the oceans by universal radiation, including ultra-violet rays, which inactivate the life-inducing DNA molecule. The first primitive living organisms — the prokaryotic cells — were single-celled, but lacked a nucleus and were incapable of cell-division. However, they were relatively resistant to the ultra-violet radiation, or even, according to one theory, dependent upon it. These organisms were the predominant form of life on earth for a period of some 2.4 billion years.

The prokaryotic unicellular creatures reproduced asexually through budding and fission. Generally, asexual reproduction creates identical copies unless a mutation develops, which is very infrequent. That explains the slowness of evolutionary change at this time. However, the emergence of the nucleated cell (eukaryotes) gave rise to the possibility of greater complexity. It seems likely that the evolution of the eukaryotes arose from a colony of prokaryotes. For instance, some modern prokaryotes can invade and live as components within eukaryotic cells. Some organelles (organs) of eukaryotes, have their own DNA, which must be a remnant of their formally independent existence. Life itself has certain principal features, including metabolism (the total of the chemical changes that go on in the organism) and reproduction. If we accept the continuity of nature, the simplest organism that exist today must have evolved from simpler and simpler processes. Moreover, the material bases of life are the commonest of all the elements of the Universe: hydrogen, carbon, oxygen, nitrogen.

Once life has appeared, it itself constitutes a barrier which prevents the re-emergence of life in the future. Molecular oxygen, a by-product of life, arises from the process of photosynthesis (where light is transformed into energy). "The life that we have on Earth today is, in fact, divided into two great categories long recognized by mankind — the oxygen breathing animals and the photosyn-

thetic or light-growing plants”, states Bernal. “Animals can live in the dark, but they need air to breathe, either free air or oxygen dissolved in water. Plants do not need oxygen — in fact they produce it in the sun-light — but they cannot live and grow for long in the dark. Which, therefore, came first? Or did some other form of life precede them? This alternative now seems almost certain. Detailed studies of the life histories, the internal cellular anatomy and the metabolism both of plants and animals show them to be divergently specialized dependants of some zoo-phyte. These must have been like some of the bacteria of today that can at the same time carry on the functions of animals and plants, and act both as oxidizing and as photosynthetic agents.”¹⁴

Early Life Forms

It is a striking fact that the chromosomes of all living organisms, from bacteria to humans, are similar in composition. All genes are made of the same kind of chemical substances — nucleoproteins. This is also true of viruses, the simplest known living things which stand on the threshold of organic and non-living matter. The chemical composition of the nucleoproteins permits a molecular entity to reproduce itself, the basic characteristic of life, both in genes and viruses.

Engels points out that the evolution of life cannot be understood without all kinds of transitional forms:

Hard and fast lines are incompatible with the theory of evolution. Even the borderline between vertebrates and invertebrates is now no longer rigid, just as little is that between fishes and amphibians, while that between birds and reptiles dwindles more and more every day. Between *Compsognathus* and *Archaeopteryx* only a few intermediate links are wanting, and birds' beaks with teeth crop up in both hemispheres. “Either...or” becomes more and more inadequate. Among lower animals the concept of the individual cannot be established at all sharply. Not only as to whether a particular animal is an individual or a colony, but also where in development one individual ceases and the other begins.

For a stage in the outlook on nature where all differences become merged in intermediate steps, and all opposites pass into one another through intermediate links, the old metaphysical method of thought no longer suffices. Dialectics, which likewise knows no hard and fast lines, no unconditional, universally valid ‘either...or’ which bridges the fixed metaphysical differences, and besides ‘either...or’ recognizes also in the right place ‘both this — and that’ and reconciles the opposites, is the sole method of thought appropriate in the highest degree to this stage. Of course, for everyday use, for the small change of science, the metaphysical categories retain their validity.¹⁵

The boundary-lines between living and non-living matter, between plants and animals, reptiles and mammals, are not so clearly drawn as one might suppose. Viruses, for example, form a class which cannot be said to be life as we generally understand it, and yet they clearly possess some of the attributes of life. As Ralph Buchsbaum states:

The viruses are among the largest proteins known, and several different ones have already been prepared in pure crystalline form. Even after repeated crystallizations, a treatment no obviously living substance has ever been able to survive, viruses resume their activities and multiply when returned to favorable conditions. While no one has yet succeeded in growing them in the absence of living matter, it is clear that viruses help to bridge the gap that was formerly thought to exist between nonliving and living things. No longer can it be said that there is some sharp and mysterious distinction between the nonliving and the living, but rather there seems to be a gradual transition in complexity.

If we imagine that the earliest self-propagating substances were something like viruses, it is not difficult to suppose that an aggregation of virus-like proteins could lead to the development of larger bacteria-like organisms, independent, creating their own food from simple substances, and using energy from the sun.

Such a level of organization may be compared to present-day forms like the independent bacteria, some of which conduct photosynthesis without chlorophyll, using, instead, various green or purple pigments. Others utilize the energy derived from the oxidation of simple salts of nitrogen, sulphur, or iron. These, for instance, can oxidize ammonia to nitrates, or hydrogen sulphide to sulphates, with the release of energy which is utilized in forming carbohydrates.¹⁶

The relatively brief interval between the formation of the planet and the cooling of its surface crust, meant that the emergence of life occurred in an amazingly short space of time. Stephen J. Gould explains that “life, for all its intricacy, probably arose rapidly about as soon as it could.”¹⁷ The microfossils of 3.5 billion years are, as expected, prokaryotic cells — that is without a nucleus (methanogens, bacteria, and blue-green algae). They are regarded as the simplest forms of life on earth, although even by this time there was diversity. Which means that between 3.5 and 3.8 billion years our common ancestor emerged, together with other forms that became extinct.

There was little, if any molecular oxygen atmosphere at this time. The organisms that existed at the time did not require oxygen — in fact it would have killed them. They grew by oxidizing hydrogen and reducing carbon dioxide to methane. It has been suggested that these organisms must have been similar to eocyte cells that inhabit the very hot environment of volcanic vents. They

obtain their energy not from oxygen but through converting sulphur to hydrogen sulphide.

“One can visualize,” writes Richard Dickerson, “that before living cells evolved the primitive ocean was teeming with droplets possessing special chemistries that survived for a long time and then disappeared again.” He continues:

Those droplets that by sheer chance contained catalysts able to induce ‘useful’ polymerizations would survive longer than others; the probability of survival would be directly linked to the complexity and effectiveness of their ‘metabolism.’ Over the aeons there would be a strong chemical selection for the types of droplets that contained within themselves the ability to take molecules and energy from their surroundings and incorporate them into substances that would promote the survival not only of the parent droplets but also of the daughter droplets into which the parents were dispersed when they became too big. This is not life, but it is getting close to it.¹⁸

Given the lack of fossil evidence, it is necessary to examine the organization of modern cells in order to cast light on their origins. For the simplest life forms to reproduce, a genetic apparatus containing nucleic acids must be present. If cells are the basic unit of life, we can be almost certain that the original organisms contained nucleic acids or closely related polymers. Bacteria, for example, are composed of a single cell and are likely to be the prototype of all living cells.

The bacterium *Escherichia coli* (*E. coli*) is so small that a million million of its cells could be enclosed into a volume of one cubic centimeter. It contains a cell wall, a membrane, which keeps essential molecules enclosed; it also selects and draws in useful molecules from outside the cell. It maintains the balance between the cell and its environment. The main metabolism of the cell takes place in the membrane, where hundreds of chemical reactions take place that use the nutrients in the environment for growth and development. The bacterium, *E. coli*, reproduces every twenty minutes. This unique transformation within the cell is made possible by a group of molecules called enzymes. These are catalysts which speed up the chemical reactions without being altered in the process. They work repeatedly, continuously transforming nutrients into products.

Reproduction is an essential element of life. When cell division occurs, a set of identical daughter cells is created. The mechanism for duplication, for making new protein molecules with exactly the same sequence as the parent cell, is encoded in the nucleic acids. They are unique in that they alone, with the

assistance of certain enzymes, are able to reproduce themselves directly. The DNA (deoxyribonucleic acid) carries all the information needed to direct the synthesis of new proteins. However, the DNA cannot do this directly, but acts as a “master copy” from which messenger RNA (ribonucleic acid) copies are made, which carry the information of the sequence to the synthesizing system. This is known as the genetic code. Nucleic acids cannot replicate without enzymes, and enzymes cannot be made without nucleic acid. They must have developed in parallel. It is likely that in the original “soup” of elements there existed RNA molecules that were also enzymes, which developed on the basis of natural selection. Such RNA enzymes came together to form a helix, and become the basis for self-replicating RNA. The genetic replication is, however, not without occasional errors. In the bacterium *E. coli* the error rate is one in every 10 million base copies. In the course of millions of generations such errors — mutations — may have little effect, but alternatively, they may lead to profound changes in the organism, and on the basis of natural selection, lead to the formation of new species.

The next stage in organic evolution was the development of other polymers — combination of molecules — grouped together into whole families. A structure was needed to enclose the molecules: a semipermeable cell membrane. Cell membranes are complex structures, barely poised between a solid and liquid state. Small changes in the composition of the membrane can produce a qualitative change, as Chris Langton explains: “Twitch it ever so slightly, change the cholesterol composition a bit, change the fatty acid composition just a bit, let a single protein molecule bind with a receptor on the membrane, and you can produce big changes, biologically useful changes.”¹⁹

Photosynthesis and Sexual Reproduction

As can be seen from what has already happened, the evolution of the cell is a relatively advanced stage of organic evolution. As the abundant components of the biotic soup became exhausted, it became necessary to evolve water-soluble organic materials from the atmosphere. From fermentation, the simpler but less efficient form of metabolism, photosynthesis was the next step. The special chlorophyll molecule had evolved. This allowed living organisms to capture solar energy for the synthesis of organic molecules. The first photosynthesizers removed themselves from the competition for dwindling natural energy-rich molecules and set themselves up as primary producers. Once the photosynthetic

process was achieved, the future of life was assured. As soon as it emerges and produces enough oxygen, respiration becomes possible. In accordance with the laws of natural selection, once photosynthesis started it made its mark on all subsequent living things, and was undoubtedly so successful that it wiped out earlier forms of life.

This development represents a qualitative leap. The subsequent evolution to more complex forms is a drawn out process eventually leading to a new branch of life, the nucleated cell. At the top of the eukaryotic tree, several branches appear simultaneously, such as plants, animals and fungi. According to the American molecular biologist Mitchell Sogin the amount of oxygen affected the pace of evolution. The chemical composition of ancient rocks suggests that atmospheric oxygen increased in relatively distinct steps separated by long periods of stability. Some biologists believe that the explosion of life could have been triggered by oxygen reaching a certain level.

The nucleated cell — the eukaryotes — completely adapted to oxygen and showed little variation. The emergence of this revolutionary new life form allowed the existence of advanced sexual reproduction, which in turn, accelerated the pace of evolution. Whereas the prokaryotes consisted of only two groups of organisms, the bacteria and the blue-green algae (the latter produced oxygen through photosynthesis), the eukaryotes consist of all green plants, all animals and fungi. Sexual reproduction represent another qualitative leap forward. This requires the genetic material to be packaged inside the nucleus. Sexual reproduction allows the mixing of genes between two cells, the chances of variation being far greater. In reproduction, the chromosomes of the eukaryotic cells fuse to produce new cells. Natural selection serves to preserve favorable genetic variants in the gene pool.

One of the key aspects of life is reproduction. All animal and plant cells have the same basic internal structures. Reproduction and the passing on of parental characteristics (heredity) takes place through the union of sex cells, the egg and sperm. The genetic material DNA through which the characteristics of life forms are transmitted from one generation to the next is contained in the nucleus of all cells. The cell structure which is made up of cytoplasm also contains a number of miniature organs called organelles. The internal structure of the organelles is identical to different types of bacteria, which seems to indicate that the composition of the animal and plant cell is the result of these once independent organs, with their own DNA, combining to form a co-operative whole. In the 1970s microtubules were discovered. These are protein

rods which fill every cell in the body like an internal scaffolding. This internal “skeleton” gives shape to the cell and appears to play a role in the circulation of protein and plasma products. The advent of the eukaryotic or nucleated cell constituted a biological revolution some 1,500 million years ago.

From asexual budding and fission emerged sexual reproduction. Such an advance served to mix up the hereditary material of two individuals, so that the offspring would differ from the parents. This provided the variation on which natural selection could work. In every animal and plant cell the DNA is arranged in pairs of chromosomes in the nucleus. These chromosomes carry the genes which determine individual characteristics. The new offspring, while combining the characteristics of its parents, is nevertheless different from them. It appears that the origin of sexual reproduction is connected with primitive organisms ingesting one another. The genetic material of two individuals were fused producing an organism with two sets of chromosomes. The larger organism then split into two parts with the correct amount of chromosomes. Single and paired chromosomes existed, but through time the paired condition became the normal mode of existence of plants and animals. This laid the basis for the evolution of multicellular organisms.

By about 700-680 million years ago, the first metazoa appeared. These were complex multicellular organisms that require oxygen for their growth. During that period the oxygen content of the atmosphere increased constantly, reaching its present level only 140 million years ago. The processes at work in evolution have a markedly dialectical character in which long periods of gradual quantitative change are interrupted by sudden explosions. Such a period occurred about 570 million years ago.

The Cambrian Explosion

It requires an effort of the imagination to recall just how recent a phenomenon complex forms of life on earth are. Picture a world in which the earth consisted of barren windswept rocks, in which the most complex forms of life were mats of algae and pond scum. This was the situation for the great majority of the earth's history. For thousands of millions of years the development of life was virtually static. Then suddenly, this stagnant world suddenly erupted in one of the most dramatic explosions in the history of life. The fossil record now reveals an extraordinary proliferation of different forms of life. The emergence of animals with shells and skeletons preserves this progress

in tablets of stone. The explosion of new forms of life in the oceans was paralleled by the mass extinction of the older stromatolites, which had been the dominant life-form in the Proterozoic period. The appearance of a vast multitude of many-celled creatures transformed the face of the earth for all time.

F. H. T. Rhodes writes:

Perhaps the most remarkable (and also the most perplexing) thing about the fossil record is its beginning. Fossils first appear in appreciable numbers in rocks of the Lower Cambrian age, deposited about 600 million years ago. Rocks of older (Pre-Cambrian) age are almost completely unfossiliferous, although a few traces of ancient organisms have been recorded from them. The difference between the two groups of rocks is every bit as great as this suggests: a paleontologist may search promising-looking Pre-Cambrian strata for a lifetime and find nothing (and many have done just this); but once he rises up into the Cambrian, in come the fossils — a great variety of forms, well-preserved, world-wide in extent, and relatively common. This is the first feature of the oldest common fossils, and it comes as a shock to the evolutionist. For instead of appearing gradually, with demonstrably orderly development and sequence — they come in with what amounts to a geological bang.²⁰

In spite of his genius, Darwin was unable to come to terms with the Cambrian explosion. Clinging to his gradualist conception of evolution, he assumed that this sudden leap was only apparent, and due to the incompleteness of the fossil record. In recent years, new and startling discoveries in paleontology have led to a major revision in the interpretation of evolution. The old idea of evolution as an uninterrupted process of gradual change has been challenged in particular by Stephen Jay Gould, whose investigations into the fossil record of the Burgess Shale (an important fossil location in British Columbia) have transformed paleontology.

Life developed, not in a straight line of uninterrupted evolutionary progress, but through a process aptly described by Stephen Jay Gould as punctuated equilibria in which long periods of apparent stability are interrupted by periods of sudden and cataclysmic change characterized by mass extinctions of species. For 500 million years the border-lines of geological periods are marked by such sudden upheavals in which the disappearance of some species clears the way for the proliferation of others. This is the biological equivalent of the geological processes of mountain formation and continental drift. It has nothing in common with the vulgar caricature of evolution understood as a simple process of gradual change and adaptation.

According to the classical theory of Darwin the emergence of the first complex multicellular forms of life must have been preceded by a long period of

slow progressive change, which culminated in the “Cambrian explosion” 500 million years ago. However, the most recent discoveries show that this is not the case. The investigations of Gould and others show that for two-thirds of the history of life on earth — nearly 2.5 billion years — life remained confined to the lowest recorded level of complexity, prokaryotic cells, and nothing else.

Another 700 million years of the larger and much more intricate eukaryotic cells, but no aggregation to multicellular animal life. Then, in the 100-million year wink of a geological eye, three outstandingly different faunas — from Ediacara to Tommotian, to Burgess. Since then, more than 500 million years of wonderful stories, triumphs, and tragedies, but not a single new phylum, or basic anatomical design, added to the Burgess complement.

In other words, the emergence of complex multicellular organisms, the basis of all life as we know it today, did not arise out of a slow, gradual “evolutionary” accumulation of adaptive changes, but in a sudden, qualitative leap. This was a veritable biological revolution, in which, “in a geological moment near the beginning of the Cambrian, nearly all modern phyla made their first appearance, along with an even greater array, of anatomical experiments that did not survive very long thereafter.” During the Cambrian period, nine phyla (the basic unit of differentiation within the animal kingdom) of marine invertebrates appeared for the first time, including protozoa, coelenterata (jellyfish, sea-anemones), sponges, mollusks and trilobites. It took about 120 million years for the complete range of invertebrate phyla to evolve. On the other hand, we had the rapid demise of the stromatolites, which had been the dominant life-form for 2 billion years.

Modern multicellular animals make their first uncontested appearance in the fossil record some 570 million years ago — and with a bang, not a protracted crescendo. This ‘Cambrian explosion’ marks the advent (at least into direct evidence) of virtually all major groups of modern animals — and all within the minuscule span, geologically speaking, of a few million years.²¹

For S. J. Gould, “We find no story of stately progress, but a world punctuated with periods of mass extinction and rapid origination among long stretches of relative tranquility.”²² And again: “The history of life is not a continuum of development, but a record punctuated by brief, sometimes geologically instantaneous, episodes of mass extinction and subsequent diversification. The geological time scale maps this history, for fossils provide our chief criterion in fixing the temporal order of rocks. The divisions of the time scale are set at

these major punctuations because extinctions and rapid diversifications leave such clear signatures in the fossil record.”²³

Plants and Animals

During the Cambrian and Ordovician period — 570-440 million years ago — there was an impressive rise of graptolites and trilobites, and a major growth of diversity in marine species all over the world, including the emergence of the first fish. This was the result of the extensive spreading of the sea floor, especially of the Iapetus Ocean. During the Silurian period (440-400 million years ago) the melting of the ice-sheets caused an important rise in the sea-level. The shallow seas that covered much of Asia, Europe and North America were not a serious barrier to the migration of species, and, not accidentally, this was the period when marine transgression reached its maximum extent.

By this time there was a somewhat odd distribution of the continents. The southern continents were loosely clustered together to form a proto-Gondwanaland (Africa, South America, Antarctica, Australia, India), but North America, Europe, and Asia were separate. There was a small proto-Atlantic Ocean (Iapetus) between Europe and North America, and the South Pole lay somewhere in North-West Africa. Subsequently, the continents drifted together to form one, single super-continent — Pangaea. This process began 380 million years ago, when the Iapetus Ocean disappeared, giving rise to the creation of the Caledonian-Appalachian mountain belt. This event resulted in the collision of the Baltic with Canada, uniting Europe with North America. By that time, continuing convergence caused the northwest corner of Gondwanaland to impinge on North America, creating a semi-continuous landmass, in which all continents were united.

Such a massive increase in land area in turn produced a revolutionary leap in the evolution of life itself. For the first time, a form of life attempted to move from the sea to the land, at its coastal margins. The first amphibians and land plants appeared. This was the starting-point for an explosive growth of animal and plant life. That period was marked by the elimination of the shallow seas environment, and, as a consequence, the mass extinction or sharp decline of many marine species. Evidently, the changing environment forced some species to move from the coastal areas to the land, or die. Some were successful, others not. The great majority of marine organisms adapted to life in the shelves and the reefs of the shallow seas became extinct. Amphibians eventually gave rise to

reptiles. The first land plants underwent an explosive growth, creating huge forests with trees reaching heights of 30 meters. Many of the coal deposits now being exploited have their origin in this remote period, the products of the accumulated debris of millions of years, rotting on the floor of prehistoric forests.

Formal logic approaches the natural world with an ultimatum — either...or. A thing is either living or dead; an organism is either a plant or an animal, and so on. In reality, things are no so simple. In *Anti-Dühring*, Engels writes: “For everyday purposes we know and can definitely say, e.g., whether an animal is alive or not. But, upon closer inquiry, we find that this is sometimes a very complex question, as the jurists very well know. They have cudged their brains in vain to discover a rational limit beyond which the killing of the child in its mother’s womb is murder. It is just as impossible to determine the moment of death, for physiology proves that death is not a sudden instantaneous phenomenon, but a very protracted process.”²⁴

We have already pointed out the difficulty in classifying very primitive organisms, such as viruses which stand on the borderline between organic and inorganic matter. The same difficulty arises in distinguishing between plants and animals. Plants fall into three major divisions. The first (*Thallophyta*) includes the most primitive forms, either single-celled organisms, or loosely organized groups of cells. Are these plants or animals? It may be argued that they are plants because they contain chlorophyll. They “live” like plants.

Rhodes has this to say on the subject:

But this simple answer does not solve our problem of recognizing a plant — if anything, it makes it more confusing, for instead of providing a convenient clear-cut dividing line between plants and animals it points us to the hazy overlapping zone between the two kingdoms. And just as the viruses carried us back to the threshold of life, so these lowly thallophytes carry us to the ill-defined threshold that separates the plant world from the animal.

Now many of the protozoans are, as we have seen, clearly animals — they move, grow, assimilate food, and excrete waste products very much as “undoubted” animals do. But there are some tantalizing exceptions. Let us look for a moment at the tiny unicellular organism *Euglena*, a common inhabitant of ponds and ditches. It has a more or less oval body which is moved through the water by movements of the flagellum; the creature can also crawl and perform worm-like movement: in other words it is capable of typically “animal” movement — but it contains chlorophyll and obtains nutrition by photosynthesis!

Euglena is really a living contradiction to most of our ideas about the differences between animals and plants, and the contradiction arises, not because we can’t

decide which of the two it is, but because it appears to be both. Other forms which are very closely related lack chlorophyll and behave as any other animal, using the long thread-like lash to swim, taking in and digesting food, and so on. The implication of this is clear. “Plants” and “animals” are abstract categories of our own making — conceived and formulated purely as a matter of convenience. Because of this, it by no means follows that all organisms must fit into one group or the other. Perhaps *Euglena* is a living remnant of the ancient and primitive group of minute aquatic organisms which were the ancestors of both animals and plants. But can we not resolve the conflict by considering chlorophyll as distinctive? Can we suppose that “if chlorophyll — then a plant” will give us a sage rule? Unfortunately this too will not do, for some of these thallophytes (the fungi) which in other respects are very plant-like, do not possess chlorophyll. In fact, these fungi represent a problem family — for in various members within it, almost all the “typical” plant characters (need for sunlight, absence of movement, and so on) break down. And yet, on balance, its members seem to be plants.²⁵

The diversity of multicellular life represents a further qualitative leap in the evolution of life. The change from soft-bodied organism to ones with mineralized hard parts, as recorded in the Burgess Shale, represents the development of higher organisms. Certain substances like salt and calcium soak into the cell structure and tissues of sea creatures, which need to secrete them. Within the cell, the organelles which deals with metabolism or energy, mitochondria, absorb calcium and phosphate and ejects it as calcium phosphate. This mineral can be deposited within cells or can be used to build an internal or external skeleton.

The development of a skeleton usually takes place through the seeding of mineral crystals onto fibrous protein, called collagen. Collagen, which makes up around a third of all protein of vertebrates, can only be formed in the presence of free oxygen. The first move towards vertebrates seems to be the *Pikaia* of the Burgess Shale, a fish-like animal. The sea-squirts also appear to be an evolutionary link between those animals that were fixed to the sea floor and obtained their food from filtered nutrients, and free-swimming fish. These fishes (ostracoderms) were covered with shell-like scales, with no teeth or jaws. This revolutionary leap in the Silurian period produced the first vertebrates.

It was in this period (410 million years ago) that the jaws evolved from the front gill, which allowed the hunting of other animals instead of sucking nutrition from the sea floor. “The first fishes did not have jaws,” says Gould. “How could such an intricate device, consisting of several interlocking bones, ever evolve from scratch? ‘From scratch’ turns out to be a red herring. The bones were present in ancestors, but they were doing something else — they were supporting a gill arch located just behind the mouth. They were well designed

for their respiratory role; they had been selected for this alone and ‘knew’ nothing of any future function. In hindsight, the bones were admirably pre-adapted to become jaws. The intricate device was already assembled, but it was being used for breathing, not eating.” This was clearly a case, in Marxist terms, of elements of the new within the old. The first jawed fish, the acanthodians, or spiny sharks, gave rise to many kinds of bony fish. From these fishes evolved the first land vertebrates, the amphibians.

Gould continues:

Similarly, how could a fish’s fin ever become a terrestrial limb? Most fishes build their fins from slender parallel rays that could not support an animal’s weight on land. But one peculiar group of freshwater bottom-dwelling fishes — our ancestors — evolved a fin with a strong central axis and only a few radiating projections. It was admirably pre-adapted to become a terrestrial leg, but it had evolved purely for its own purposes in water — presumably for scuttling along the bottom by sharp rotation of the central axis against the substrate.

In short, the principle of pre-adaption simply asserts that a structure can change its function radically without altering its form as much. We can bridge the limbo of intermediate stages by arguing for a retention of old functions while new ones are developing.²⁶

The Eusthenopteron had muscular fins, and lungs as well as gills. During dry periods, these fishes ventured from the pools to breath air through their lungs. Many of the Carboniferous amphibians spent much of their time on land, but returned to water to lay their eggs. From there, the evolutionary leap was in the direction of reptiles, which spent all their time on land and laid fewer eggs enclosed in a calcium carbonate shell. Commenting on these leaps in evolution, Engels writes: “From the moment we accept the theory of evolution all our concepts of organic life correspond only approximately to reality. Otherwise there would be no change. On the day when concepts and reality completely coincide in the organic world development comes to an end. The concept fish includes life in water and breathing through gills: how are you going to get from fish to amphibian without breaking through this concept? And it has been broken through, for we know a whole series of fish which have developed their air bladders further, into lungs, and can breathe air. How, without bringing one or both concepts into conflict with reality, are you going to get from egg-laying reptile to the mammal, which gives birth to living young? And in reality we have in the monotremata a whole sub-class of egg laying mammals — in 1843 I saw the eggs of the duck-bill in Manchester and with arrogant narrow-mindedness

mocked at such stupidity — as if a mammal could lay eggs — and now it has been proved!”²⁷

Mass Extinctions

The Paleozoic-Mesozoic boundary (250 million years ago) represents the greatest period of extinction in the entire fossil record. Marine invertebrates were especially affected. Whole groups became extinct, including the trilobites which had dominated the oceans for millions of years. Plant life was not seriously affected but 75% of amphibians and over 80% of reptile families disappeared. At present, it is estimated that four or five families disappear every million years. But at the end of the Paleozoic, we had the disappearance of 75-90% of all species. By such catastrophic events did the evolution of the species unfold. Yet this process of mass extinctions did not represent a step back in the evolution of life. On the contrary, precisely this period prepared a mighty step forward in the development of life on earth. The gaps left in the environment by the disappearance of some species gave an opportunity to others to rise, flourish and dominate the earth.

The factors which influence the distribution, diversity and extinctions of life forms are endlessly varied. Furthermore, they are dialectically interrelated. Continental drift itself causes changes of latitude, and therefore climatological conditions. Variations in climate will create environments that are more or less favorable for different organisms. Tolerance to temperature fluctuations and climatic conditions are key factors in this process, giving rise to diversification. We see that diversity usually increases as we get closer to the equator.

The break-up of continents, their separation and collisions, all these factors change the conditions under which the species develop, cutting off one group from another. Physical isolation produces new adaptive variations, reflecting changes in the environment. Continental fragmentation thus tends to increase the diversity of life-forms. Kangaroos survived only because Australia was isolated from the other continents very early, before the explosive rise of the mammals which caused the disappearance of large marsupials in all the other continents. Similarly, the destruction of oceans produces mass extinctions of marine species, yet at the same time creates the conditions for the development of new land plants and animals, as was the case at the inception of the Pangaeon land mass. Death and birth are thus inseparably linked in the chain of evolutionary development, where the mass extinction of one species is the prior

condition for the emergence and development of new ones, better equipped to cope with changed conditions.

The evolution of the species cannot be regarded as an isolated self-contained fact, but must be seen as the result of a constant and complex interaction of different elements — not only the infinitely large numbers of genetic mutations within living organisms, but also the continual changes in the environment: fluctuations in sea-level, water salinity, the circulation of oceanic currents, the supply of nutrients to the oceans, and, possibly, even factors like the reversal of the earth's magnetic field, or the impact of large meteorites on the earth's surface. The dialectical interplay of these diverse tendencies is what conditions the process of natural selection, which has produced forms of life far richer, more varied and more wonderful than the most fantastic inventions of poetry.

12. THE REVOLUTIONARY BIRTH OF MAN

The Epoch of the Dinosaurs — the Mesozoic (850-65 million year ago)

The continental mass, Pangaea, created through the collision of the continents in the Paleozoic era, remained intact for about 100 million years. This gave rise to a new set of tectonic, climatic and biological conditions. Then in the Mesozoic era the process turned into its opposite. The super-continent began to break up. Vast glaciers covered the southern parts of Africa-America-Australia and Antarctica. During the Triassic (250-205 million years ago) dinosaurs evolved on the land and pleisiosaurus and ichthyosaurus in the sea, while the winged reptile pterosaurus later took to the air. Mammals evolved from the thraspid reptiles, but they developed very slowly. The explosive growth of the dinosaurs which dominated other vertebrate terrestrial life-forms did not permit a major development of mammals. They remained small both in size and numbers for millions of years, eclipsed by the shadow of their giant contemporaries, searching for food at night.

The Jurassic (205-145 million years ago) saw a major climatic change marked by the retreat of the glaciers, leading to a rise in global temperature towards the end of the period. The level of the seas rose by at least 270 meters during the Mesozoic, reaching almost double the present average level.

It takes a long time to fragment a supercontinent. The break-up of Pangaea began at the beginning of the Jurassic (180 million years ago) and the last continent was not separated until the early Cenozoic (40 million years ago). The

first separation was on an east-west axis, where the creation of the Tethys Ocean split Pangaea into Laurasia in the North and Gondwanaland in the South. In turn, Gondwanaland split into three parts in the east — India, Australia and Antarctica. During the late Mesozoic a North-South split appeared, creating the Atlantic Ocean which separated north America from Laurasia and South America from Africa. India moved to the north and collided with Asia, while Africa also moved to the north and partly collided with Europe after the destruction of the Tethys Ocean. Of this mighty ocean, only a tiny part remained as the Mediterranean Sea. In the Pacific, Atlantic and Indian Oceans, periods of rapid expansion of the sea floor assisted the movement of the continental fragments.

Throughout the Mesozoic, dinosaurs were the dominant group of vertebrates. Despite the separation of the continents, they were firmly established all over the world. But at the end of this period — 65 million years ago — there was a new period of mass extinctions, in which the dinosaurs vanished from the face of the earth. Most of the terrestrial, marine and flying reptiles (dinosaurs, ichthyosaurs and pterosaurs) were wiped out. Of the reptiles, only the crocodiles, snakes, turtles and lizards survived. This spectacular elimination of species was not confined to the dinosaurs, however. In fact, about one-third of all living species became extinct, including the ammonites, belemnites, some plants, bryozoa, bivalve mollusks, echinoids and others.

The remarkable success of the dinosaurs was a result of their perfect adaptation to the existing conditions. The total population was at least as big as that of mammals today. At present, everywhere in the world, there is a mammal, big or small, occupying every available ecological space. We can be sure that 70 million years ago, those spaces were occupied by an immense variety of dinosaurs. Contrary to the common impression of the dinosaurs as huge, lumbering creatures, they existed in all sizes. Most were relatively small, many walked upright on their hind legs, and could run very fast. Many scientists now believe that at least some of the dinosaurs lived in groups, looked after their young, and possibly even hunted in packs. The Mesozoic-Cenozoic boundary (65 million years ago) represents yet another revolutionary turning-point in the evolution of life. A period of mass extinction prepared the way for a huge evolutionary leap forward, opening the way for the rise of the mammals. But before we deal with this process, it is worth while considering the question of why the dinosaurs disappeared.

Why did the Dinosaurs Disappear?

This question has been hotly debated in recent years, and, despite very confident claims, particularly on behalf of the meteorite-catastrophe theory, is still not decisively resolved. There are in fact many theories which have attempted to explain a phenomenon which, both because of its spectacular appearance and because of its implications for the emergence of our own species, has captured the popular imagination in a unique way. Nevertheless, it is necessary to remind ourselves that this was not a unique event in the chain of evolution. It was not the only mass extinction, or the biggest, or necessarily the one with the most far-reaching evolutionary consequences.

The theory which currently enjoys most support and which certainly has been given the most sensational publicity is based on the assertion that the impact of a huge meteorite falling somewhere on the earth's surface caused an effect rather similar to the "nuclear winter" which would follow a major nuclear war. If the impact were sufficiently large, it would throw great quantities of dust and debris into the atmosphere. The dense clouds thus formed would prevent the sun's rays from reaching the earth's surface, resulting in a prolonged period of darkness and falling temperatures.

There is empirical evidence to suggest that some kind of explosion took place, which may have been caused by a meteorite. The theory has gained ground in recent years with the discovery of a thin layer of clay amongst fossil remains, which would be consistent with the effect of dust produced by such a large impact. The idea has, for example, seemingly been accepted by Stephen J. Gould. Nevertheless, there are questions which have still to be answered. First of all, the dinosaurs did not disappear overnight, or even in a few years. In fact, the extinction occurred over several million years — a very short time in geological terms, but sufficiently long to cast some doubt on the idea of a meteoric catastrophe.

While the meteorite hypothesis cannot be ruled out, it has one major disadvantage. As we have pointed out, there have been many mass extinctions along the evolutionary road. How is this to be explained? Do we really have to resort to an external phenomenon such as a sudden meteor impact to do so? Or does the rise and fall of species have something to do with tendencies that are inherent within the process of evolution itself? Even at the present time, we can observe the phenomenon of the rise and fall of animal populations. Only recently have we come close to understanding the laws which govern this complex

process. By looking for explanations that lie outside the given phenomenon, we run the risk of abandoning the search for a real understanding. Moreover, a solution which seems attractive because it removes all difficulties at a stroke can create even greater difficulties than the ones it was alleged to have solved.

Several other suggestions have been put forward. The period under consideration was characterized by widespread volcanic activity. This, and not a meteorite impact, could well have caused a change in the climate which the dinosaurs were unable to cope with. It has also been suggested that the disappearance of the dinosaurs was connected with competition from the mammals. There is a parallel here with the disappearance of most of the original marsupial population of South America under pressure from the mammals from the North. Indeed, it is possible that the extinction of these creatures was the result of a combination of these circumstances — volcanic activity, destruction of the existing environment, excessive specialization, and competition for reduced food resources by a species better-equipped to cope with the changed conditions. It is unlikely that this particular controversy will be resolved in the near future. What is not in dispute is that, at the end of the Mesozoic some fundamental change ended the domination of the dinosaurs. The main thing is that it is not necessary to introduce external factors to explain this phenomenon:

“You don’t have to look for sunspots, climatic upheavals or any other weird explanation to account for the disappearance of the dinosaurs,” said Lovejoy. “They did fine as long as they had the world to themselves, as long as there was no better reproductive strategy around. They lasted more than a hundred million years; humans should as well. But once a breakthrough adaptation was made, once dinosaurs were confronted by animals that could reproduce successfully three or four times as fast as they could, they were through.”²⁸

The Cosmic Terrorist — or How Not to Make a Hypothesis

The problem becomes clear the moment we pose the question in the following way: very well, let’s accept that the extinction of the dinosaurs was caused by an accident in the form of a sudden meteorite impact. How do we explain all the other mass extinctions? Were they all caused by meteorites? The question is not as pointless as it might seem. Attempts have indeed been made to show that all the large-scale extinctions were the result of periodic storms of meteorites from the asteroid belt. This is the substance of the so-called “Nemesis theory” put forward by Richard Muller of the University of California.

Certain paleontologists (Raup and Sepkoski) have claimed that mass extinctions occur at regular intervals of approximately 26 million years. However, others basing themselves on the same evidence have found no such regularity in this phenomenon. There is a similar disagreement among geologists, some of whom claim to see evidence of regular periodicity in the occurrence of big craters, while others disagree. In short, there is no conclusive evidence either for the idea of regular intervals between mass exterminations or of regular bombardment of the earth by comets or meteorites.

Such a field lends itself easily to the most arbitrary and senseless speculations. Moreover, it is precisely such sensational “theories” which tend to get most publicity, irrespective of their scientific merit. The “Nemesis” theory is a case in point. If we accept, as Muller does, that mass exterminations occur regularly every 26 million years, and if we further accept, as he does, that mass extinctions are caused by meteorite storms, then it must follow that the earth must have been visited by meteorites every 26 million years, as regular as the clock.

The difficulty in such a notion is quite clear — even to Muller, who writes:

I found it incredible that an asteroid would hit precisely every 26 million years. In the vastness of space, even the Earth is a very small target. An asteroid passing close to the sun has only slightly better than one chance in a billion of hitting our planet. The impacts that do occur should be randomly spaced, not evenly strung out in time. What could make them hit on a regular schedule? Perhaps some cosmic terrorist was taking aim with an asteroid gun. Ludicrous results require ludicrous theories.

And Muller went on to make up precisely such a ludicrous theory, in order to justify the preconceived idea that all mass extinctions were indeed caused by meteorite impacts, and that these happen regularly every 26 million years. He describes a heated argument with Luis Alvarez, the originator of the original theory that the dinosaurs were wiped out by an asteroid crashing into the earth, who was skeptical about Muller’s ideas. The following extract from this dialogue gives us an interesting insight into the methodology whereby certain hypotheses are born:

“Suppose someday we found a way to make an asteroid hit the Earth every 26 million years. Then wouldn’t you have to admit that you were wrong, and that all the data should have been used?”

“What is your model?” he demanded. I thought he was evading my question.

“It doesn’t matter! It’s the possibility of such a model that makes your logic wrong, not the existence of any particular model.’

“There was a slight quiver in Alvarez’s voice. He, too, seemed to be getting angry. ‘Look, Rich,’ he retorted, ‘I’ve been in the data-analysis business a long time, and most people consider me quite an expert. You just can’t take a no-think approach and ignore something you know.’

“He was claiming authority! Scientists aren’t allowed to do that. Hold your temper, Rich, I said to myself. Don’t show him you’re getting annoyed.

“The burden of proof is on you,’ I continued, in an artificially calm voice. ‘I don’t have to come up with a model. Unless you can demonstrate that no such models are possible, your logic is wrong.’

“How could asteroids hit the Earth periodically? What is your model?” he demanded again. My frustration brought me close to the breaking point. Why couldn’t Alvarez understand what I was saying? He was my scientific hero. How could he be so stupid?

“Damn it! I thought. If I have to, I’ll win this argument on his terms. I’ll invent a model. Now my adrenaline was flowing. After another moment’s thought, I said: ‘Suppose there is a companion star that orbits the sun. Every 26 million years it comes close to the Earth and does something, I’m not sure what, but it makes asteroids hit the Earth. Maybe it brings the asteroids with it.’”

The completely arbitrary nature of the method used to arrive at a hypothesis without the slightest basis in fact is glaringly obvious. With such an approach, we really leave the realm of science and enter that of science fiction, where, in the words of the old song, “anything goes.” In fact, Muller himself is honest enough to confess that “I hadn’t meant my model to be taken that seriously, although I had felt that my point would be made if the model could withstand assault for at least a few minutes.”²⁹ But we live in an age of credulity. The “Nemesis” theory, which is quite clearly not a scientific model, but an arbitrary guess, is now being taken with the utmost seriousness by many astronomers who are sweeping the skies, busily searching for clues of the existence of this invisible “death-star,” this cosmic terrorist who, having made short work of the dinosaurs, will one day return to the scene of the crime, and finish us all off!

The problem here is one of method. When Napoleon asked Laplace where God fitted into his mechanical scheme of the universe, he gave the famous reply: “Sire, je n’ai pas besoin de cette hypothèse.” (“Sire, I have no need for that hypothesis.”) Dialectical materialism sets out to discover the inherent laws of

motion of nature. Whereas accident plays a role in all natural processes, and it cannot, in principle be excluded that, for example, the extinction of the dinosaurs was caused by a stray asteroid, it is completely misleading and counterproductive to seek the causes of mass exterminations in general in external phenomena, wholly unrelated to the processes under consideration. The laws which govern the evolution of the species must be sought for and found in the process of evolution itself, which includes both long periods of slow change, but also other periods where change is enormously accelerated, giving rise both to mass exterminations of some species and the emergence and strengthening of new ones.

It is the lack of ability to grasp the process as a whole, to understand its contradictory, complex, non-linear character — that is to say, the lack of a dialectical approach — which leads to these arbitrary attempts to solve problems by recourse to extraneous factors, like a *deus ex machina*, the proverbial rabbit pulled out of a conjurer's hat. Along this road lies only the deadest of dead-ends. Moreover, the extraordinary propensity for the acceptance of the wildest scenarios — almost all involving the idea of some impending cosmic catastrophe, signifying, at the very least, the end of the world — is something which tells us a lot about the general psychological make-up of society in the last decade of the 20th century.

The Revolutionary Birth of Man

The era known as the Cenozoic begins with the mass extinctions 65 million years ago and has continued right up to the present. During this era, the continents continued to drift, separate and collide. This created new environmental conditions. In the first 20 million years, temperatures continued to rise, and a tropical zone appeared, in which conditions in Britain, for example, resembled those of a Malaysian jungle. The most important development in evolution in this era was the extraordinarily rapid rise of the mammals, which took over the environments vacated by the reptiles. By 40 million years ago, primates, elephants, pigs, rodents, horses, sea cows, porpoises, whales and bats, as well as most orders of modern birds and many families of plants, had all appeared.

The rise of the mammals might be seen as a kind of triumphal procession, in which evolution progresses ever upwards, in an unbroken line, culminating finally in the birth of humankind, the crowning glory of creation. But this was far

from the case. Evolution was never a straight line, as we have seen. Periods of intense growth were, in this period also, followed by dramatic reversals, death and extinction. The two main periods of extinction are linked with sharp environmental changes. By 40-30 million years ago, we observe the beginnings of a cooling process. Temperature fell continuously for the next 25 million years, only stabilizing at its present level 5 million years ago. That period witnessed the first recent period of extinctions affecting mammals.

The primates, the ancestors of apes and of humans, were spread all over the world. The period of extinction of the dinosaurs had an effect on many of these families. The new environmental conditions led to the development of a new species — the proto-apes, better adapted to the changed conditions. It is worth mentioning that the new conditions mainly influenced Africa and Euro-Asia, and not America. By this time, Antarctica reached the South Pole and began to be covered in ice. For the next 10-20 million years, there was a further period of explosive growth of mammals — the biggest ever — in which many species of apes appeared. However, the basic design of the apes remained unchanged throughout this period, until a new sharp climatic shift brought about a transformation. There are considerable disagreements among paleontologists on the question of when and how the hominids separated from the apes. There are indications from bones that as far back as 14 million years ago there was already a species which resembled modern apes. Scientists believe that these bones belong to a species which lived both in Africa and Euro-Asia from 14-7 million years ago. It appears to have been a very successful species, and represents the common ancestor of humans, apes and gorillas. Then, 10-7 million years ago, there was a new and dramatic environmental change.

Antarctica was already covered by glaciers. Now the ice-sheet spread, not only in the South, but in the North, where it covered Alaska, North America, and North Europe. Since more and more water was trapped in the ice, the sea-level began to decline. It has been estimated that the fall in sea-levels was more than 150 meters at that time. As a result, new land-masses appeared, joining the continents; land bridges were formed connecting Europe and Africa, Asia and America, Britain and Europe, thus making possible further migrations of species. The Mediterranean Sea completely evaporated. The climate around the equator became very dry, causing extensive desertization, together with a massive decline of jungles and forests, and the emergence of vast expanses of savannahs and open land. By this time, Asia was separated from Africa by deserts, thus cutting off the African apes from their Asian cousins. Inevitably, this was

another period of extinction and death. But it was equally a period of the birth of new species. At a certain point, possibly 7 million years ago, the development of mammals resulted in the emergence of the first hominids (human-like primates).

It is now generally accepted that humankind originated in Africa. By 5.3 million years ago, the Mediterranean assumed its present form, and a new species of ape developed in Africa, which, in the course of a million years, developed in three different directions, giving rise eventually to apes, hominids and gorillas. The separation of these three branches occurred about 4-5 million years ago as a result of environmental pressure in Eastern Africa. The spread of the glaciers to South Africa resulted in a dramatic change in Eastern Africa — severe depletion of forests, because of reduced rainfall and a generally drier climate. This was probably the driving-force which led to the separation of the three species of proto-apes. Hitherto, they had lived in trees. Now they had three options:

1) Part of them remained in the forests. These must have been the most skilful, strongest and most successful in extracting food from limited sources. However, the decline of the forest habitat must have severely depleted their numbers. The remnant of this branch is represented by the modern gorillas.

2) Another group, forced to move to the margins of the forests, with fewer trees and less food resources, eventually were forced to increase their food-gathering range by moving on the ground, while remaining near the trees for protection. This group is represented by the modern chimpanzees.

3) A third group, probably made up of the weaker and less skilful section of the species, were compelled by intense competition for scarce food resources to move out of the forest altogether. They were thus forced not only to move on the ground, but to cover long distances in order to find the food necessary for their survival. They were compelled to develop an entirely new way of living, radically different to that of other primates.

Environmental pressures in Asia caused by climatic changes also drove some groups of monkeys to the fringes of the forests. These developed into the modern baboons, which move on the ground in search of food, but return to the trees for protection. Primates exhibit a variety of modes of locomotion. The tarsier leaps and clings; the gibbon swings from limb to limb; the orangutan is “four-handed”; the gorilla is a knuckle walker; the monkey is a true quadruple; only hominids have ventured to become completely bipedal.

Other specializations have gone with handedness. If one is going to jump and snatch, one had better be able to judge distances accurately. If not, one will come up empty-handed at best; at worst, one will miss the branch entirely and fall. The way to precise distance judgment is via binocular vision: focusing two eyes on an object to provide depth perception. That requires that the eyes be set in the front of the skull and facing forward, not on the sides of the head, as a squirrel's eyes are. Primate ancestors developed such vision. Their skulls become rounded to accommodate the new position of the eyes, and with that change in shape came an enlargement of the skull capacity and the opportunity to have a larger brain. At the same time, the jaw became smaller. With hands, an animal does not have to do all its foraging and hunting with its teeth. It can afford a shorter jaw and fewer teeth. Modern apes and monkeys — and humans — have sixteen teeth in each jaw. Their ancestors had as many as twenty two.³⁰

The psychologist Jerome Bruner in his writings on the mental development of children, has stressed that skilled behavior has much in common with language production on the one hand and problem-solving on the other. The simplest skills almost all involve the use of the hand or hands and the visual guidance. On the development of the human hand, Bruner writes the following:

The hands of man are a slow-growing system, and it is many years before humans can exhibit the kind of manual intelligence that has distinguished our species from others — the using and making of tools. Indeed, historically, the hands were regarded even by students of primate evolution as of no particular interest. Wood Jones would have us to believe that there was little morphological difference between the monkey hand and that of man, but that the difference was in the function to which they were put by the central nervous system. Yet, as Clark and Napier have pointed out, it is the evolutionary direction of morphological change in the hand, from tree shrews through New World monkeys through Old World monkeys to man, that should reveal how the function of the hand has changed and, with it, the nature of the implementation of human intelligence.

That change has been steadily in the direction of a very special form of despecialization. The hand is free from its locomotor function, from its brachiating function, and from such specialized requirements as were answered by claws and by exotic forms of finger pads. Becoming more despecialized in function means becoming more varied in the functions that can be fulfilled. Without losing its capacity for phalangeal divergence needed for weight-wearing, convergence for cupping food, prehensility for holding and climbing, or opposability — all part of an early primate heritage — the hand in the later primate evolution achieves several new functional capacities while undergoing appropriate morphological change as well. A combined capacity for power and precision grip is added.

The flexibility of the palm and thumb increases through changes in the hamate and trapezium bones in their articulation. The thumb lengthens and its resting angle to the hand increases. The terminal phalanges broaden and strengthen, particularly the thumb. Napier may exaggerate when he says, 'The present evidence suggests

that the stone implements of early man were as good (or as bad) as the hand that made them.' For surely, initially stupid hands become clever when employed in a clever program devised by the culture.³¹

The first hominid fossils were found in East Africa, and belong to the species known as *Australopithecus afarensis*, which lived around 3.5 — 3.3 million years ago. These ape-like creatures were able to walk upright, possessed hands with thumbs fully opposed to the fingers, and therefore capable of manipulating tools. Their cranial capacity was larger than other apes (450 ccs.). As yet, no tools have been found in connection with these early hominids, but are clearly in evidence when we come to the first clearly identifiable human species, the aptly-named *Homo habilis* ("handyman"), which walked upright, had a height of 1.20 meters and had a brain capacity of 800 cubic centimeters.

At what point does the real separation of humans from hominid apes take place? Palaeontologists have argued for a long time over this question. The answer was given by Engels in his masterly essay *The Part Played by Labor in the Transition of Ape to Man*. But it was already anticipated by Marx and Engels much earlier in their pioneering work, *The German Ideology*, written in 1845:

Men can be distinguished from animals by consciousness, by religion or anything else you like. They themselves begin to distinguish themselves from animals as soon as they begin to produce their means of subsistence, a step which is conditioned by their physical organization. By producing their means of subsistence men are indirectly producing their material life.³²

Role of Toolmaking

In an extremely superficial attempt to discredit the materialist view of the origin of the human species, it is often stated that humans are not the only animals to "use tools." This argument is completely hollow. While many animals (not only monkeys and chimpanzees, but even some birds and insects) may be said to use "tools" for certain activities, these are limited to whatever natural materials they find to hand — sticks, stones etc. Moreover, such use either consists of accidental activity, as when a monkey throws a stick to dislodge fruit from a tree, or limited actions which may be highly complex, but are entirely the result of genetic conditioning and instinct. The actions are always the same. There is no question of intelligent planning, foresight or creativity, except to a very limited degree in the higher species of mammals, but the most advanced of the apes have nothing resembling the productive activity of even the most primitive hominids.

The essential point is not that humans “use tools.” It is the fact that humans are the only animals that make tools, and not as an isolated or accidental activity, but as the essential condition for their existence upon which everything else depends. Thus, although from a genetic point of view humans and chimpanzees are almost identical, and the behavior of these animals in some respects appears remarkably “human,” the most intelligent chimpanzee is quite incapable of making even the most rudimentary stone tools produced by *homo erectus*, a creature standing on the evolutionary threshold of humanity.

In his most recent book, *The Origin of Humankind*, Richard Leakey, makes this point:

Chimpanzees are adept tool users, and use sticks to harvest termites, leaves as sponges, and stones to crack nuts. But — so far, at any rate — no chimpanzee in the wild has ever been seen to manufacture a stone tool. Humans began producing sharp edged tools 2.5 million years ago by hitting two stones together, thus beginning a trail of technological activity that highlights human prehistory.³³

Compare these lines to what Engels wrote in 1876:

Many monkeys use their hands to build nests for themselves in the trees or even, like the Chimpanzee, to construct roofs between the branches for protection against the weather. With their hands they seize hold of clubs to defend themselves against enemies, or bombard the latter with fruits and stones. In captivity, they carry out with their hands a number of simple operations copied from human beings. But it is just here that one sees how great is the gulf between the undeveloped hand of even the most anthropoid of apes and the human hand that has been highly perfected by the labor of hundreds of thousands of years. The number and general arrangement of the bones and muscles are the same in both; but the hand of the lowest savage can perform hundreds of operations that no monkey's hand can imitate. No simian hand has ever fashioned even the crudest stone knife.³⁴

Nicholas Toth has spent many years attempting to reconstruct the methods by which early humans produced tools, and has come to the conclusion that even the most basic processes of flaking stone requires not only considerable care and manual dexterity, but also a degree of foresight and planning.

“To work efficiently, the stone knapper has to choose a rock of the correct shape, bearing the correct angle at which to strike; and the striking motion itself requires great practice in order to deliver the appropriate amount of force in the right place. ‘It seems clear that early tool-making proto-humans had a good intuitive sense of the fundamentals of working stone,’ Toth wrote in a paper in 1985. ‘There’s no question that the earliest toolmakers possessed a mental

capacity beyond that of apes,' he recently told me. 'Toolmaking requires a coordination of significant motor and cognitive skills.'" ³⁵

There is a close correlation between the hand, the brain, and all the other organs of the body. The part of the brain connected with the hands is vastly greater than that which is connected with any other part of the body. Darwin already grasped the fact that the development of certain parts of the organism are linked with the development of other parts which apparently have no relation to them. He called this phenomenon the law of the correlation of growth. The development of manual dexterity through labor provided the stimulus for a rapid development of the brain.

The development of humankind was not an accident, but the result of necessity. The upright stance of early hominids was necessary to allow them to move freely on the savannah in search of food. The head had to be positioned at the top of the body in order to detect the presence of predators, as we see in some other savannah-dwelling animals, such as the meerkat. Limited food sources created the necessity to gather and transport, which was the driving force for the development of the hand.

Apes were not built to walk on two legs and do so rather clumsily. The anatomy of even the earliest hominids reveal a bone structure clearly adapted to upright walking. The upright posture has severe disadvantages in many respects. It is impossible to run as fast on two legs as on four. In many ways, bipedalism is an unnatural posture, which explains the prevalence of back-pains which have plagued the human animal from the cave to the present. The great advantage of bipedalism is that it freed the hands for labor. This was humanity's great leap forward. Labor is, together with nature, the source of all wealth. But, as Engels points out, it is infinitely more than this:

"It is the primary basic condition for all human existence, and this to such an extent that, in a sense, we have to say: labor created man himself."

The development of the hand through labor is closely connected to the development of the body as a whole.

"Thus the hand is not only the organ of labor, it is also the product of labor. Only by labor, by adaptation to ever new operations, by inheritance of the thus acquired special development of muscles, ligaments, and, over longer periods of time, bone as well, and by the ever-renewed employment of these inherited improvements in new, more and more complicated operations, has the human hand attained the high degree of perfection that has enabled it to conjure into

being the pictures of Raphael, the statues of Thorwaldsen, the music of Paganini.

“But the hand did not exist by itself. It was only one member of an entire, highly complex organism. And what benefited the hand, benefited also the whole body it served.”³⁶

The same thing applies to language. Even though apes are capable of producing a range of sounds and gestures which may be seen as a kind of embryonic “language,” all attempts to teach them to talk have ended in failure. Language, as Engels explains, is a product of collective production, and can only arise in a species the life-activity of which depends exclusively on co-operation in order to produce tools, a complex process which must be consciously learnt and passed on from one generation to the next. On this, Noam Chomsky remarks:

Anyone concerned with the study of human nature and human capacities must somehow come to grips with the fact that all normal humans acquire language, whereas acquisition of even its barest rudiments is quite beyond the capacities of an otherwise intelligent ape.

In recent times, it has become customary to try to show that language is not peculiar to humans. While there is no doubt that systems of communication exist among animals, it is entirely incorrect to describe this as language. Human speech arises from human society and human co-operative productive activity, and is qualitatively different to any other system of communication in the animal world, even the most complex.

Human language appears to be a unique phenomenon, without significant analogue in the animal world. If this is so, it is quite senseless to raise the problem of explaining the evolution of human language from more primitive systems of communication that appear at lower levels of intellectual capacity.

And again:

As far as we know, possession of human language is associated with a specific type of mental organization, not simply a higher degree of intelligence. There seems to be no substance to the view that human language is simply a more complex instance of something to be found elsewhere in the animal world. This poses a problem for the biologist, since, if true, it is an example of true ‘emergence’ — the appearance of a qualitative different phenomenon at a specific stage of complexity of organization.

³⁷

The rapid expanse in brain size brought additional problems, especially in relation to child-birth. Whereas a newborn ape has a brain size of 200 cubic

centimeters — about half that of an adult — that of a human baby (385 cubic centimeters) is only about a quarter of the size of the adult human brain (about 1350 cubic centimeters). The form of the human pelvis, adapted to walking in an upright position limits the size of the pelvic opening. Thus, all human babies are born “prematurely,” as a result of the large brain and the restrictions imposed by the biological engineering of bipedalism.

The complete helplessness of the newborn human baby is evident in comparison with any other species of higher mammals. It has been suggested by Barry Bogin, a biologist at the University of Michigan, that the slow rate of bodily growth in human infants, as compared to apes, is connected with the long time needed to absorb the complex rules and techniques of human society. Even the difference in body-size between children and adults helps to establish a teacher-pupil relationship, where the young learn from the old, whereas among the apes rapid growth soon leads to physical rivalry. When the long process of learning is complete, the body catches up with a sudden leap in growth during adolescence.

Humans become human through intense learning not just of survival skills but of customs and social mores, kinship and social laws — that is, culture. The social milieu in which helpless infants are cared for and older children are educated is much more characteristic of humans than it is of apes.³⁸

Social Organization

Life on the open savannah with a multitude of predators was a dangerous affair. Humans are not strong animals, and the early hominids were much smaller than modern humans. They possessed neither strong claws nor powerful teeth, nor could they outrun lions and other four-footed predators. The only way to survive was by developing a highly organized and co-operative community for the collective exploitation of scarce food resources. But the decisive step was without doubt the manufacture of artifacts, beginning with the stone scrapers, used for a variety of purposes. Despite their deceptively simple appearance, these were already highly sophisticated and versatile tools, the production of which implies a significant degree of organization, planning, and at least the elements of a division of labor. Here we have the real beginnings of human society. In the words of Engels:

As already said, our simian ancestors were gregarious; it is obviously impossible to seek the derivation of man, the most social of all animals, from non-gregarious immediate ancestors. The mastery over nature, which begins with the development

of the hand, with labor, widened man's horizon at every new advance. He was continually discovering new, hitherto unknown, properties of natural objects. On the other hand, the development of labor necessarily helped to bring the members of society closer together by multiplying cases of mutual support, joint activity, and by making clear the advantage of this joint activity to each individual. In short, men in the making arrived at the point where they had something to say to one another. The need led to the creation of its organ; by modulation the undeveloped larynx of the ape was slowly but surely transformed for ever more developed modulation, and the organs of the mouth gradually learned to pronounce one articulate letter after another.³⁹

The production of tools, the beginnings of a division of labor, originally between men and women, the development of language, and a society based on co-operation — these were the elements which marked the real emergence of humankind. This was not a slow, gradual process, but represents yet another revolutionary leap, one of the most decisive turning-points in evolution. In the words of the paleontologist Lewis Binford, "Our species had arrived — not as a result of gradual, progressive processes but explosively in a relatively short period of time."⁴⁰

The relation between labor and all the other factors was explained by Engels:

First labor, after it, and then with it, articulate speech — these were the two most essential stimuli under the influence of which the brain of the ape gradually changed into that of man, which for all its similarity to the former is far larger and more perfect. Hand in hand with the development of the brain went the development of its most immediate instruments — the sense organs. Just as the gradual development of speech is necessarily accompanied by a corresponding refinement of the organ of hearing, so the development of the brain as a whole is accompanied by a refinement of all the senses. The eagle sees much farther than man, but the human eye sees considerably more in things than does the eye of the eagle. The dog has a far keener sense of smell than man, but it does not distinguish a hundredth part of the odors that for man are definite features of different things. And the sense of touch, which the ape hardly possesses in its crudest initial form, has been developed only side by side with the development of the human hand itself, through the medium of labor.

The earliest hominids had a predominantly vegetarian diet, although the use of even the most primitive tools like digging-sticks gave them access to supplies of food not available to other apes. This diet was supplemented by small quantities of meat, obtained mainly by scavenging. The real breakthrough came when the production of tools and weapons permitted humans to pass over to hunting as the primary source of food.

The consumption of meat undoubtedly led to a rapid further increase in brain size. "A meat diet," writes Engels, "contains in an almost ready state the most essential substances required by the organism for its metabolism. It shortened the time required, not only for digestion, but also for the other vegetative bodily processes corresponding to those of plant life, and thus gained further time, material, and desire for the active manifestation of animal life in the proper sense of the term. And the further that man in the making became removed from the plant kingdom, the higher he rose also above animals. Just as becoming accustomed to a plant diet side by side with meat converted wild cats and dogs into the servants of man, so also adaptation to a flesh diet, side by side with a vegetable diet, considerably contributed to giving bodily strength and independence to man in the making. The most essential effect, however, of a flesh diet was on the brain, which now received a far richer flow of the materials necessary for its nourishment and development, and which therefore could become more rapidly and perfectly developed from generation to generation." ⁴¹

Exactly the same point is made by Richard Leakey, who relates it to a fundamental change in social organization. In most other primates, there is fierce competition between males to mate with the females. This is reflected in the very considerable differences in body size between, say, male and female savannah baboons. Such a difference can be seen in the earliest hominids, such as *Australopithecus afarensis*. This suggests a social structure closer to the apes than to humans. In other words, physical adaptations such as bipedalism, vital as it undoubtedly was as a precondition for human evolution, does not yet entitle us, contrary to what Richard Leakey suggests, to characterize these early hominids as humans.

Among savannah baboons, the males (who are twice the size of the females) leave the troop as soon as they reach maturity, and join another troop, where they immediately enter into competition with the established males for access to the females. Thus, in Darwinian terms, these males have no (genetic) reason for co-operating with each other. Among chimpanzees, on the other hand, for reasons not yet understood, the males remain in the group where they were born, and the females migrate. The male chimpanzees, being genetically related, have a Darwinian reason to co-operate, which they do, both to defend the group against outsiders, and even occasionally combining to hunt a monkey to supplement their diet. The difference in body-size between male and female chimpanzees is only 15-20%, reflecting the predominantly co-operative nature of this society.

Whereas the difference in size between male and female members of the *Australopithecus afarensis* group was so great that they were at first thought to be fossils from two entirely different species, the situation is radically different when we come to the earliest members of the human species, where males were no more than 20% larger than females, as with chimpanzees, our closest genetic relatives. On this, Leakey remarks:

As the Cambridge anthropologists Robert Foley and Phyllis Lee have argued, this change in body-size differential at the time of the origin of the genus *Homo* surely represents a change in social organization, too. Very probably, early *Homo* males remained with their natal groups with their brothers and half brothers, while the females transferred to other groups. Relatedness, as I've indicated, enhances co-operation among the males.

We can't be certain what prompted this shift in social organization: enhanced co-operation among males must have been strongly beneficial for some reason. Some anthropologists have argued that defense against neighboring troops of *Homo* became extremely important. Just as likely, and perhaps more so, is a change centered on economic needs. Several lines of evidence point to a shift in diet for *Homo* — one in which meat became an important energy and protein source. The change in tooth structure in early *Homo* indicates meat eating, as does the elaboration of a stone-tool technology. Moreover, the increase in brain size that is part of the *Homo* package may even have demanded that the species supplement its diet with a rich energy source.⁴²

It is well-known that the brain is a metabolically expensive organ, which in modern humans absorbs 20% of energy consumed, despite only amounting 2% of total body weight. The Australian anthropologist Robert Martin has explained that the increase in brain size in early *Homo* could only have occurred on the basis of an enhanced energy supply, which could only come from meat, with its concentration of calories, proteins and fat. Originally, this would have come from scavenging, and some hunting activity (which, as we know, occurs even among chimpanzees). But later there is little doubt that hunting played an increasing role in providing a more varied and nutritional diet, with far-reaching evolutionary consequences.

Hypotheses on Human Development

In recent years, there has been a fierce controversy about the role of hunting in early human society. There has been a tendency to play down the role of hunting, insisting more on the role of food gathering and scavenging. While this question is still not decisively resolved, it is difficult not to share Leakey's

view that the argument against the hunter-gatherer model of early human society has gone too far. It is also interesting to note the way in which these controversies tend to reflect certain prejudices or social pressures and fads which have nothing whatsoever to do with the issues at stake.

In the early years of the 20th century, the idealist standpoint predominated. Mankind became human thanks to the brain, with its higher thoughts, which propelled all development. Later, the view of “Man the Toolmaker” re-emerged, although in a rather idealized version, in which tools, but not weapons, were said to be the motor-force of evolution. The terrible events of the Second World War then produced a reaction against this, in the form of the theory of “Man the Killer Ape,” put forward “possibly because it seemed to explain (or even excuse) the horrible events of the war,” as Leakey shrewdly remarks

In the 1960s, there was a great interest in the !Kung San — the incorrectly named “Bushmen” of the Kalahari desert, a group of people living in apparent harmony with their natural environment, and exploiting it in complex ways. This fitted in well with the growing interest in environmental issues in Western society. In 1966, however, the idea of “Man the Hunter” re-emerged strongly at a major anthropological conference in Chicago. This, however, fell foul of the supporters of “Women’s Liberation,” in the 1970s. Since hunting is usually seen as a male activity, it was assumed — quite unjustifiably — that to accept it would be somehow to downgrade the role of women in early society. The powerful feminist lobby put forward the hypothesis of “Woman the Gatherer,” in which it was argued that the gathering of food, mainly plants, which could be shared, was the basis on which a complex human society evolved.

The central role of women in early society is undeniable, and was clearly explained by Engels in his classic work *The Origins of the Family, Private Property and State*. However, it is a serious error to read into the record of the past conceptions — or, still worse, prejudices — derived from present-day society. The cause of the emancipation of women will not be advanced a single step by attempting to make the reality of history fit into a pattern which appeals to certain current fashions but is devoid of any real content. We do not make the future of humanity any more hopeful by painting the past in rosier colors. Nor will we encourage people to become vegetarians by denying the fundamental role played by meat-eating, hunting, yes, and even cannibalism, in developing the human brain.

With all respect to the vegetarians, it has to be recognized that man did not come into existence without a flesh diet, and if the latter, among all peoples known to us,

has led to cannibalism at some time or another (the forefathers of the Berliners, the Weletabians or Wilzians, used to eat their parents as late as the tenth century), that is of no consequence to us today.⁴³

Similarly, a division of labor must have existed between men and women in the earliest human societies. The mistake, however, is to confuse the division of labor in early society, where neither private property nor the family as we know it today existed, with inequality and the oppression of women in modern class society. In the majority of existing hunter-gatherer societies known to anthropologists, the elements of a division of labor exists, in which the men hunt and the women gather plants for food.

The camp is a place of intense social interaction, and a place where food is shared [comments Leakey], when meat is available, this sharing often involves elaborate ritual, which is governed by strict social rules.

There is good reason to suppose that a similar situation existed in early human society. Instead of the caricature of Social Darwinism, which attempts to extrapolate the laws of the capitalist jungle to cover the whole of human history and prehistory, all the available evidence indicates that the entire basis of early human society was co-operation, collective activity, and sharing. Glynn Isaac of Harvard University made a significant advance in anthropological thinking in a major article published in *Scientific American* in 1978. Isaac's food sharing hypothesis emphasizes the social impact of collective food gathering and sharing. In a 1982 speech on the centenary of Darwin's death, he said: "The adoption of food-sharing would have favored the development of language, social reciprocity and the intellect." In his latest book, *The Making of Mankind*, Richard Leakey wrote that "the food-sharing hypothesis is a strong candidate for explaining what set early humans on the road to modern man."

The last 2 million years have been characterized by a unique climate cycle. Long periods of intense cooling and glacier advances have been interrupted by short periods of rising temperatures and glacial retreat. Ice ages have an average duration of 100,000 years, whereas the interglacial periods last for approximately 10,000. Under these extreme conditions, mammals were compelled to develop more advanced forms or to disappear. Out of a total of 119 mammalian species living in Europe and Asia 2 million years ago, only nine still survive. The big majority of the rest either developed as more advanced species, or disappeared. Once again, birth and death are inseparably linked in the contradictory, bitter-sweet, dialectical process of evolution.

The last ice age gave way to a new inter-glacial period, which has lasted until the present, but will eventually come to an end. *Homo erectus* gave way to a more advanced hominid — *Homo sapiens* — about five hundred thousand years ago. The human race (*Homo Sapiens sapiens*) represents one evolutionary line from *Homo sapiens*, branching off about a hundred thousand years ago. The other line — *Homo sapiens neanderthalensis* — either disappeared or was absorbed around 40,000 years ago. Thus, the human race developed during a period characterized by intense cooling. These conditions represented a severe struggle for survival. However, there were other periods in which conditions improved, stimulating massive growth and waves of human migration. The age of humankind begins to dawn.

Engels and Human Origins

How do the ideas of Engels, *The Part Played by Labor in the Transition of Ape to Man*, stand in the light of the most recent theories of evolution?

One of the foremost modern paleontologists is Stephen J. Gould. In his book *Ever Since Darwin*, he gives the following appraisal of Engels' essay:

"Indeed, the nineteenth century produced a brilliant exposé from a source that will no doubt surprise most readers — Frederick Engels. (A bit of reflection should diminish surprise. Engels had a keen interest in the natural sciences and sought to base his general philosophy of dialectical materialism upon a 'positive' foundation. He did not live to complete his 'dialectics of nature,' but he included long commentaries on science in such treatises as the *Anti-Dühring*.) In 1876, Engels wrote an essay entitled, *The Part Played by Labor in the Transition from Ape to Man*. It was published posthumously in 1896 and, unfortunately, had no visible impact upon Western science.

"Engels considers three essential features of human evolution: speech, a large brain, and upright posture. He argues that the first step must have been a descent from the trees with subsequent evolution to upright posture by our ground-dwelling ancestors. 'These apes when moving on level ground began to drop the habit of using their hands and to adopt a more and more erect gait. This was the decisive step in the transition from ape to man.' Upright posture freed the hand for using tools (labor, in Engels' terminology); increased intelligence and speech came later." ⁴⁴

Despite everything, idealist theories of human evolution still conduct a stubborn rearguard action against materialism, as we see from the following extract from a book published as recently as 1995:

“The force that is likely to have driven our evolution (is)...the process of cultural evolution. As our cultures evolved in complexity, so did our brains, which then drove our bodies towards greater responsiveness and our cultures towards still greater complexity in a feedback loop. Big and clever brains led to more complex cultures and bodies suited to take advantage of them, which in turn led to yet bigger and cleverer brains.”⁴⁵

Idealists have repeatedly attempted to assert that man is distinguished from the “lower” animals by his superior intelligence. Evidently, early man, for some unexplained reason, first “became intelligent,” then began to speak, use tools, paint pictures and so on. If this were true, one would expect it to be reflected in a significant increase in brain size very early on. However, the fossil record proves that this is not the case.

In the course of the last three decades, there have been a series of tremendous advances in the science of paleontology, new and exciting fossil discoveries and a new way of interpreting them. According to one recent theory, the first bipedal apes evolved as far back as 7 million years ago. Subsequently, in a process known to biologists as “adaptive radiation,” there was a proliferation of bipedal species (that is, species which walked on two legs), with the evolution of many different species of bipedal apes, each adapted to different environmental conditions. About 2-3 million years ago, one of these species developed a significantly larger brain — *Homo erectus*. These were the first hominids to use fire; to use hunting as a significant source of food; to run in the same way as modern humans and to make tools according to a definite preconceived mental plan. Thus, the increase in brain size coincides with the first appearance of tool-making activity, approximately 2.5 million years ago. Thus, for 5 million years, there was no significant expansion of brain size, and then a sudden leap which is clearly identified with the production of tools.

Molecular biology indicates that the earliest hominid species appeared about five million years ago, in the form of a bipedal ape with long arms and curved fingers. The proto-human *Australopithecus* had a small brain — only 400 cubic centimeters. The qualitative leap took place with *Homo habilis*, who had a brain size of more than 600 cubic centimeters — i.e., an astonishing increase of 50%. The next big advance was with *Homo erectus*, with a brain size of between 850 and 1100 cubic centimeters.

Not until the emergence of *Homo sapiens* about two hundred and fifty thousand years ago does the size of the brain reach modern levels — 1350 ccs. Thus, the earliest hominids did not possess large brains. Human evolution was not powered by the brain. On the contrary, the enlarged brain was the product of human evolution, especially the making of tools. The qualitative leap in brain size takes place with *Homo habilis* and is clearly identified with the production of stone tools. In fact a new qualitative leap takes place in the transition from *Homo erectus* to *Homo sapiens*. “The human mind appeared on Earth with astonishing suddenness,” writes John McCrone. “Just 70,000 years — the merest eye-blink of geological time — covers our ancestors’ transition from smart ape to self-conscious *Homo sapiens*.”

“On the far side of the evolutionary divide stands *Homo erectus*, a clever beast with a brain almost as big as a modern human’s, a simple tool culture and a mastery of fire — yet mentally still somehow lacking. On our own side stands *Homo sapiens* with the rituals and symbolic art — the cave paintings, beads and bracelets, decorative lamps and burial graves — that mark the arrival of a self-aware mind. Something sudden and dramatic must have happened, and it is this event that could be the starting point for human consciousness.”⁴⁶

Can Apes Make Tools?

It has recently become fashionable to blur the difference between humans and the rest of the animal kingdom to the point where it virtually disappears. In a way, this is preferable to the kind of idealist nonsense of the past. Humans are animals, and share a number of characteristics with other animals, especially our nearest relatives, the apes. The genetic difference between humans and chimpanzees is only about two percent. Yet here too, quantity becomes quality. This two percent represents a qualitative leap which has decisively separated humankind from all other species.

The discovery of the rare species of bonobo chimpanzees, who are even closer to humans than other chimpanzees, has aroused a lot of interest. In their book *Kanzi, The Ape at the Brink of the Human Mind*, Sue Savage-Rumbaugh and Roger Lewin have given a detailed account of their investigations into the mental capacities of a captive bonobo, Kanzi. There is no doubt that the level of intelligence displayed by Kanzi is significantly higher than that so far seen in non-humans, and in some respects resembles that of a human child. Above all, it

shows the existence of the potential for, say, tool-making. This is a powerful argument in favor of the theory of evolution.

Nevertheless, the significant thing about the experiments which attempt to get the bonobo to make a stone tool, is that they were unsuccessful. In the wild, chimpanzees use “tools” such as “fishing sticks” to get termites out of their nest, and even use stones as “anvils” to crack nuts. These operations show a high level of intelligence, and undoubtedly prove that humankind’s nearest relations possess some of the mental prerequisites needed for more advanced activities. But as Hegel once remarked, when we want to see an oak-tree, we are not satisfied if we are shown an acorn instead. The potential for making tools is not the same as actually making them, any more than the mere possibility of winning £10 million on the lottery is the same thing as actually winning. Moreover, this potential, on closer examination turns out to be extremely relative.

Modern chimpanzees occasionally hunt small monkeys. But they do not use weapons or tools for this; they use their teeth. Early humans were able to butcher large carcasses, for which they needed sharp stone tools. No doubt, the earliest hominids used only ready-made implements like sticks for digging up roots. This is just the kind of thing we see with modern chimpanzees. If humans had stuck to a mainly vegetarian diet, there would have been no need to make stone tools. But the ability to make stone tools gave them access to a whole new supply of food. This remains true even if we accept that early humans were not hunters but mainly scavengers. They would still need stone tools to cut through the tough hides of large animals.

The proto-humans of the Oldowan culture in East Africa already possessed quite advanced techniques for making stone tools by the process known as flaking. They selected the right sort of stones, and rejected others; they used the correct angle for striking and so on. All this shows a high level of sophistication and skill, which is absent from the “work” of Kanzi, despite the active intervention of humans aimed at encouraging the bonobo to produce a tool. After repeated efforts, the experimenters were forced to admit that:

“So far Kanzi has exhibited a relatively low degree of technological finesse in each of [the four criteria] compared to that seen in the Early Stone Age record.”

And they conclude:

“There is, therefore, a clear difference in the stone-knapping skills of Kanzi and the Oldowan tool-makers, which seems to imply that these early humans had indeed ceased to be apes.”⁴⁷

Among other differences separating even the most primitive hominids from the highest of the apes are important changes in body-structure related to the upright stance. The structure of the bonobo's arms and wrists, for instance, is different from that of humans. The long, curled fingers and short thumb prevent it from gripping a stone effectively enough to strike a powerful glancing blow. This fact has already been pointed out by others:

The chimpanzee's hand has a fairly well developed opposable thumb, "but it is stubby and meets the forefinger along its side, not at its tip. In the hominid hand, the thumb is much larger and is twisted so that it faces the forefinger. This is a logical concomitant to bipedalism and produces a great increase in dexterity. All hominids seem to have had this kind of hand — even *afarensis*, the oldest one now known. Its hand is scarcely distinguishable from a modern man's." ⁴⁸

Despite all the efforts to blur the dividing lines, the difference between even the most advanced apes and the most primitive hominids has been established beyond doubt. Ironically, these experiments, intended to disprove the idea of humans as tool-making animals, proved exactly the opposite.

Humans and Language

In the same way that attempts have been made to show that tool-making is not a fundamental feature of humanity, so some have tried to show the same thing in relation to language. The part of the brain known as Broca's area is associated with language, and was thought to be unique to humans. It is now known that this area also exists in other animals. This fact has been used to dispute the idea that the acquisition of language is unique to humans. But this argument seems extremely feeble. The fact remains that no species other than humans depend upon language for their existence as a species. Language is essential to the social mode of production, which is the basis of human society.

In order to prove that other animals can communicate to some extent, it is not necessary to study the behavior of bonobos. Many of the lower species have quite sophisticated systems of communication — not just mammals, but also birds and insects. Ants and bees are social animals and have highly developed forms of communication. These, however, cannot be taken as implying intelligent thought, or thought at all. They are inborn and instinctive. They also are quite limited in scope. The same actions are repeated endlessly and mechanically and are no less effective for that. But few would regard this as language as we understand it.

A parrot can be taught to repeat whole sentences. Does this mean it can talk? It is fairly clear that, while it can imitate sounds quite well, it has no understanding of what the sounds actually mean. But the conveyance of meaning is the essence of intelligible language. Things are different with the higher mammals. Engels, who was a keen hunter, was not sure to what extent dogs and horses did not partially understand human speech and feel frustrated at not being able to talk. Certainly, the level of understanding shown by the bonobo Kanzi in captivity is quite remarkable. In spite of all this, there are specific reasons why no animal other than humans have a language. Humans alone possess a vocal tract that permits the production of consonants. No other animal can pronounce consonants. Some can make clicking and hissing sounds. In fact, consonants can only be pronounced together with vowels, or they would be reduced to clicks and hisses. The ability to pronounce consonants is a product of walking on two feet, as the study on Kanzi shows:

Man alone has a vocal tract that permits the production of consonants sounds. These differences between our vocal tract and that of apes, while relatively minor, are significant and may be linked to the refinement of bipedal posture and the associated need to carry the head in a balanced, erect position over the center of the spine. A head with a large heavy jaw would cause its bearer to walk with a forward list and would inhibit rapid running. To achieve balanced upright posture, it was essential that the jaw structure recede and thus that the sloped vocal tract characteristic of apes become bent at a right angle. Along with the reduction of the jaw and the flattening of the face, the tongue, instead of residing entirely in the mouth, was lowered partially down into the throat to form the back of the oropharynx. The mobility of the tongue permits modulation of the oropharyngeal cavity in a manner that is not possible in the ape, whose tongue resides entirely in the mouth. Similarly, the sharp bend in the supralaryngeal airway means that the distance between the soft palate and the back of the throat is very small. By raising the soft palate, we can block off the nasal passage-ways, permitting us to form the turbulence necessary to create consonants.

Without consonants, we cannot easily distinguish between one word and another. We would just have howls and screeches. These can convey a certain amount of information, but it is necessarily limited:

“Speech is infinitely varied and currently only the human ear can readily find the meaningful units in these infinitely varied patterns. The consonants permit us to accomplish this feat.” Human infants are able to categorize consonants in a way similar to adults from a very early age, as anyone who has listened to “baby talk” will know. It consists precisely of constantly repeated experiments with combinations of consonants and vowels — “ba-ba, pa-pa, ta-

ta, ma-ma,” and so on. Even at this early stage, the human infant is performing a task which no other animal is capable of.

Should we then conclude that the only reason that other animals lack speech is physiological? That would be a serious mistake. The shape of the vocal tract, and the physical ability to combine vowels and consonants are the physical preconditions for human speech, but no more than that. Only the development of the hand, inseparably connected with labor and the need to develop a highly co-operative society, made possible the enlarged brain and language. It seems that the area of the brain related to the use of tools and language have a common origin in the early development of the nervous system of a child, and only become separated from the age of two, when Broca's area establishes differentiated circuits with the anterior prefrontal cortex. This, in itself, is striking proof of the close link between tool-making and language. Language and manipulative skills developed together, and this evolution is reproduced in the development of human infants today.

Even the earliest hominids of the Oldowan culture had manipulative skills far in advance of the apes. They were not just “upright chimpanzees.” The manufacture of even the simplest stone tool is far more complex than it seems. It requires planning and foresight. *Homo habilis* had to plan ahead. He had to know that at some time in the future he would need a tool, even though, he had no such need in the moment when he discovered the appropriate material. The careful selection of the right kind of stone, and the rejection of others; the searching out of the right angle to strike a blow; this showed a level of thinking ability qualitatively different to that of apes. It seems unlikely that at least the rudiments of language were not present at this stage. But there is further evidence which points in this direction. Humans are unusual in that 90% are right-handed. Such a preference for one hand is not found in other primates. Individual apes may be right-handed or left-handed, but the population as a whole will break down into two equal halves. The phenomenon of handedness is closely connected with manipulative skills and language:

Handedness is associated with localization of function to the opposite brain hemisphere. The location of manipulative skills in the left hemispheres of (most) right-handers is accompanied by the location there of language skills, too. The right hemisphere has become specialized for spatial skills.

This phenomenon is absent in *Australopithecus*, but has been found in the earliest known skulls of *Homo habilis*, the first toolmaker. It is highly unlikely that

this is a coincidence. By the time we reach *homo erectus*, the evidence becomes overwhelming:

These three lines of anatomical evidence — of the brain, the vocal apparatus, and the capacity for tool-use — provide the principal support for the notion of long, gradual changes on the road to language. Along with these changes in the brain and the vocal apparatus, there occurred concomitant gradual changes in the hand, changes that made it an increasingly suitable instrument for tool construction and use.⁴⁹

The emergence of humankind represents a qualitative leap in evolution. Here, for the first time, matter becomes aware of itself. In place of unconscious evolution, we have the commencement of history. In the words of Frederick Engels:

With man we enter history. Animals also have a history, that of their descent and gradual evolution to their present position. This history, however, is made for them, and in so far as they themselves take part in it, this occurs without their knowledge and desire. On the other hand, the more that human beings become removed from animals in the narrower sense of the word, the more they make their history themselves, consciously, the less becomes the influence of unforeseen effects and uncontrolled forces on this history, and the more accurately does the historical result correspond to the aim laid down in advance.

If, however, we apply this measure to human history, to that of even the most developed peoples of the present day, we find that there still exists here a colossal disproportion between the proposed aims and the results arrived at, that unforeseen effects predominate, and that the uncontrolled forces are far more powerful than those set into motion according to plan. And this cannot be otherwise as long as the most essential historical activity of men, the one which has raised them from the animal to the human state and which forms the material foundation of all their other activities, namely the production of their requirements of life, i.e., in our day social production, is above all subject to the interplay of unintended effects from uncontrolled forces and achieves its desired end only by way of exception, but much more frequently the exact opposite...

Only conscious organization of social production, in which production and distribution are carried on in a planned way, can lift mankind above the rest of the animal world as regard the social aspect, in the same way that production in general has done this for mankind in the specifically biological aspect. Historical evolution makes such an organization daily more indispensable, but also with every day more possible. From it will date a new epoch of history, in which mankind itself, and with mankind all branches of its activity, and particularly natural science, will experience an advance that will put everything preceding it in the deepest shade.⁵⁰

13. THE GENESIS OF MIND

The Brain Puzzle

Organic nature grew out of dead nature; living nature produced a form capable of thought. First, we had matter, incapable of thought; out of which developed thinking matter, man. If this is the case — and we know it is, from natural science — it is plain that matter is the mother of mind; mind is not the mother of matter. Children are never older than their parents. “Mind” comes later, and we must therefore consider it the offspring, and not the parent...matter existed before the appearance of a thinking human; the earth existed long before the appearance of any kind of “mind” on its surface. In other words, matter exists objectively, independently of “mind.” But the psychic phenomena, the so-called “mind,” never and nowhere exists without matter, were never independent of matter. Thought does not exist without a brain; desires are impossible unless there is a desiring organism...In other words: psychic phenomena, the phenomena of consciousness, are simply a property of matter organized in a certain manner, a “function” of such matter.” (Nikolai Bukharin)

The interpretation of brain mechanisms represents one of the last remaining biological mysteries, the last refuge of shadowy mysticism and dubious religious philosophy. (Steven Rose)

For centuries, as we have seen, the central issue of philosophy was the question of the relation between thought and being. Now at last the great strides forward made by science are beginning to shed light on the real nature of the mind and how it works. These advances provide striking confirmation of the materialist outlook. This is particularly the case in relation to the controversies over the brain and neurobiology. The last hiding-place of idealism is under attack, which does not prevent the idealists from staging a stubborn rear-guard action, as the following quotation shows:

When it became impossible to investigate this non-material element of creation many dismissed it. They came to think that only matter was real. And so our deepest thoughts were reduced to nothing but the products of brain cells working according to the laws of chemistry...We may study the electrical brain responses that accompany thought, but we cannot reduce Plato to nerve pulses, or Aristotle to alpha-waves...Descriptions of physical movements will never reveal their meaning. Biology can only examine the interlocking world of neurons and synapses.⁵¹

What we call “mind” is just the mode of existence of the brain. This is an immensely complicated phenomenon, the product of many millions of years of evolution. The difficulty in analyzing the complex processes that occur within the brain and nervous system, and the equally complex interrelations between mental processes and the environment, has meant that a proper understanding of the nature of thought has been delayed for centuries. This has enabled

idealists and theologians to speculate on the allegedly mystical nature of the “soul,” conceived as a non-material substance which deigned to take up temporary residence in the body. The advances of modern neurobiology mean that the idealists are finally being driven from their ultimate refuge. As we begin to unlock the secrets of the brain and nervous system, it becomes progressively easier to explain the mind, without recourse to supernatural agents, as the sum total of brain activity.

In the words of neurobiologist Steven Rose, mind and consciousness are “the inevitable consequence of the evolution of particular brain structures which developed in a series of evolutionary changes in the pathway of humanity’s emergence... consciousness is a consequence of the evolution of a particular level of complexity and degree of interaction among the nerve cells (neurons) of the cerebral cortex, while the form it takes is profoundly modified for each individual brain by its development in relationship with the environment.”⁵²

The Mind — a Machine?

The conceptions of the human brain have changed considerably over the past 300 years, since the birth of modern science and the emergence of capitalist society. The way in which the brain has been perceived has historically been colored by the existing religious and philosophical prejudices. For the Church, the mind was “God’s house.” The mechanistic materialism of the 18th century regarded it as a clockwork machine. More recently, it has been described as an improbable sum of probabilistic events. In mediaeval times, when the Catholic ideology dominated everything, the soul was said to permeate all portions of the body; brain, body, mind or matter were indistinguishable. With the appearance of Copernicus, Galileo and finally Newton and Descartes, with its views of mechanical materialism, there was a shift in this viewpoint.

For Descartes the world was machine-like, and living organisms merely particular types of clockwork or hydraulic machines. It is this Cartesian machine image which has come to dominate science and to act as the fundamental metaphor legitimating a particular world view, which takes the machine as a model for the living organism and not the reverse. Bodies are indissoluble wholes that lose their essential characteristics when they are taken to pieces. Machines, on the contrary, can be dismantled to be understood and then put back together. Each part serves a separate and analyzable function, and the whole operates in a

regular manner that can be described by the operation of its separate parts impinging on each other.

At each stage, the image of the brain has faithfully reflected the limitations of the science of the period. The mechanistic world-outlook of the 18th century reflected the fact that the most advanced science of the day was mechanics. Had the great Newton not explained the entire universe in terms of the laws of mechanics? Why then should the human body and mind work in any other way? Descartes accepted this point of view when he described the human body as a kind of automaton. But since Descartes was a devout Catholic, he could not bring himself to accept that the immortal soul could be part of this machine. It had to be something entirely separate, situated in a special area of the brain, the so-called pineal gland. From this obscure corner of the brain, the Spirit took up temporary residence in the body, and gave life to the machine.

Steven Rose says,

So developed the inevitable but fatal disjunction of Western scientific thought, the dogma known in Descartes' case and that of his successors as "dualism"; a dogma which, as we shall see, is the inevitable consequences of any sort of reductionist materialism which does not in the end wish to accept that humans are "nothing but" the motion of their molecules. Dualism was a solution to the paradox of mechanism which would enable religion and reductionist science to stave off for another two centuries their inevitable major contest for ideological supremacy. It was a solution which was compatible with the capitalist order of the day because in weekday affairs it enabled humans to be treated as mere physical mechanisms, objectified and capable of exploitation without contradiction, while on Sundays ideological control could be reinforced by the assertion of the immortality and free will of an unconstrained incorporeal spirit unaffected by the traumas of the workday world to which its body has been subjected.⁵³

In the 18th and 19th centuries, the conception of the mind being the "ghost in the machine" changed. With the advent of electricity, the brain and nervous system were perceived as an electrical maze. At the turn of the century, the telephone exchange analogy emerges, where the brain processes messages from different organs. With the era of mass production came the model of business organization, as typified in this quote from a child's encyclopedia:

Imagine your brain as the executive branch of big business. It is divided, as you see here, into many departments. Seated at the big desk in the headquarters office is the General Manager — your conscious self — with telephone lines running to all departments. Around you are your chief assistants — the Superintendents of Incoming Messages, such as Vision, Taste, Smell, Hearing, and Feeling (the last two hidden behind the central offices). Nearby also are the Superintendents of Outgoing Messages which control Speech and the movement of Arms, Legs, and all other

parts of the body. Of course, only the most important messages ever reach your office. Routine tasks such as running the heart, lungs, and stomach, or supervising the minor details of muscular work are carried out by the Managers of Automatic Actions in the Medulla Oblongata and the Manager of Reflex Actions in the Cerebellum. All other departments form what the scientists call Cerebrum.

With the advent of the computer, which can carry out staggering calculations, the parallel with the brain became inevitable. The very way computers stored information was called memory. More and more powerful computers were built. How close could a computer get to the human brain? Eventually, science fiction brought us the Terminator films, where computers had surpassed human intelligence and fought to take over the world. Yet as Steven Rose in his latest book explains: "Brains do not work with information in the computer sense, but with meaning. And meaning is a historically and developmentally shaped process, expressed by individuals in interaction with their natural and social environment. Indeed, one of the problems of studying memory is precisely that it is a dialectical phenomenon. Because each time we remember, we in some senses do work on and transform our memories; they are not simply being called up from store and, once consulted, replaced unmodified. Our memories are recreated each time we remember." ⁵⁴

What is the Brain?

The human brain is the highest point attained by evolution of matter. Physically it weighs about 1.5 kilograms, which is heavier than most human organs. Its surface is wrinkled like a walnut and has a color and consistence resembling cold porridge. It is, however, extremely complex biologically. It contains a vast number of cells (neurons), possibly numbering 100 billion in total. But even this is dwarfed when we discover that each neuron is embedded in a mass of smaller cells called glia, which serves to support the neurons.

The brain is largely composed of the cerebrum, which is divided into two equal parts. The surface area is known as the cortex. The size of the cortex distinguishes humans from all other organisms. The cerebrum is split into regions or lobes, which correspond roughly to particular body functions and in processing sensory information. Behind the cerebrum lies the cerebellum, which supervises all the tiny muscular movements of the body. Below these parts is a thick stalk or brain stem, which is the continuation of the spinal cord. This carries the nerve fibers from the brain through the spinal cord and throughout

the body's nervous system, bringing everything into communication with the brain.

The increased brain size which decisively sets humans apart from other animals is mainly accounted for by the enlargement of the thin outer layer of nerve cells known as the neocortex. However, this expansion did not take place uniformly. The frontal lobes, associated with planning and foresight, expanded much more than the rest. The same is true of the cerebellum, at the rear part of the skull, which is associated with the ability to acquire automatic skills, a host of everyday actions which we perform without thinking, such as riding a bike, changing gear while driving or doing up pajama buttons.

The brain itself contains a circulatory system that brings nutrients to regions distant from a blood supply. It receives a large proportion of blood, which carries vital oxygen and glucose. Although the adult brain makes up only 2% of body weight, its oxygen consumption is 20% of the total — and as much as 50% in an infant. Twenty percent of the body's glucose consumption occurs in the brain. Fully one fifth of the blood pumped by the heart passes through the brain. The nerves transmit information electrically. The signal that passes down a nerve does so as a wave of electricity; a pulse which passes from the cell body to the end of the nerve fiber. So the language of the brain is composed of electrical impulses, not only the amount but the frequency. "The information upon which such predictions are based," writes Rose, "depends on the arrival of data at the body surface in terms of light and sound of varying wavelengths and intensities, fluctuations in temperature, pressure on particular points of the skin, concentration of certain chemical substances which are detected by nose or tongue. Within the body this data is transformed into a series of electrical signals passing along particular nerves to the central brain regions where the signals interact with one another producing certain types of response."

The neuron is composed of a whole number of properties (dendrites, cell body, axon, synapses), which carry out this relay of information (messages arrive at the synapses from the axon). In other words, the neuron is the unit of the brain system. Thousands of motor neurons are involved in any coordinated muscular action. More complex actions will involve millions — though even a million represents only about 0.01 per cent of the total available in the human cortex. But the brain cannot be understood as an assemblage of separate parts. While analysis of the detailed make up of the brain is vital, it can only go so far.

"There are many levels at which one can describe the behavior of the brain," states Rose. "One can describe the quantum structure of atoms, or the molecular

properties of the chemicals which compose it; the electron-micrographic appearance of the individual cells within it; the behavior of its neurons as an interacting system; the evolutionary or developmental history of these neurons as a changing pattern in time; the behavioral response of the individual human whose brain is under discussion; the familial or social environment of that human, and so on.”⁵⁵ In order to understand the brain, it is necessary to grasp the complex dialectical interrelations of all its parts. It is necessary to bring together a whole host of sciences: ethology, psychology, physiology, pharmacology, biochemistry, molecular biology, and even cybernetics and mathematics.

Evolution of the Brain

In ancient mythology, the goddess Minerva sprang fully armed from the head of Jupiter. The brain was not so fortunate. Far from being created in a single instant, it evolved into its present complex system over a period of millions of years. It came into existence at quite a primitive level of evolution. Single celled organisms show certain behavior patterns (e.g. movement towards light or nutrients). With the advent of multi-cellular life, a sharp division takes place between animal and plant life. While possessing internal signaling devices which enable plants to “communicate,” plant evolution turned away from the evolution of nerves and brain. The movement in the animal kingdom required rapid communication between cells in different parts of the body.

The simplest organisms are self sufficient, possessing all their requirements within a single cell. Communication between one part of the cell and another is relatively simple. On the other hand, multi-cellular organisms are qualitatively different and permit the development of specialization between cells. Certain cells can deal primarily with digestion, others providing a protective layer, and others circulation, etc. Chemical signaling (hormones) exists in the most primitive multicellular organisms. Even at such a primitive level specialized cells can be found. It is a step towards a nervous system. The more complex organisms, such as flatworms have developed a nervous system, where the neurons are clustered together into a ganglion. It has been established that the ganglion is the evolutionary link between nerves and the brain. These clumps of nerve cells occur in insects, crustaceans and mollusks.

The development of a head and the location of eye spots and mouth are an advantage in receiving information about the direction in which the animal is moving. In conformity with this development a group of ganglia are clustered in

the head of a flatworm. It represents the evolution of the brain — despite its primitive form. The flatworm also exhibits learning — a key property of the developed brain. It represents a revolutionary leap forward in evolutionary terms.

Over a decade ago, American neuroscientists found that the basic cellular mechanisms for the formation of memory in humans are also present in snails. Professor Eric Kandel of Columbia University studied the learning and memory of a marine snail called *Aplysia californica*, and found that it exhibited some basic features found in humans. The difference is that, while the human brain has some 100 billion nerve cells, *Aplysia* only has a few thousand, and they are large. The fact that we share these mechanisms with a marine snail is a sufficient answer to the stubborn attempts of idealists to present humankind as some kind of unique creation, separate and apart from other animals. For almost every function of the brain depends in some way upon memory. No divine intervention is required to explain this phenomenon. Natural processes tend to be very conservative. Having hit upon an adaptation which proves useful for performing certain functions, it is constantly replicated throughout evolution, enlarged and improved upon to the degree that this bestows an evolutionary advantage.

Evolution has introduced many innovations in the brains of animals, especially the higher primates and humans with their very large brains. Whereas *Aplysia* can “remember” something for several weeks, its memory only involves a level of mental activity known as habit in humans. Such a memory is involved in, say, remembering how to swim. Research into brain-damaged people suggest that the faculty of remembering facts and habit are stored separately in the brain. A person can lose his memory for facts, but still ride a bicycle. The memories that fill a human mind are, of course, infinitely more complex than the processes that go on in the nervous system of a snail.

The continued enlargement of the brain required a drastic change in animal evolution. The nervous system of arthropods or mollusks cannot develop further as a result of a fundamental design problem. The nerve cells are arranged in a ring around the gut, and if expanded would increasingly restrict the gut — a limit sharply revealed in the spider, where the gut is so narrowed by its nerve ring that it can only digest its food as a thin liquid. Insects cannot grow beyond a certain size as their structures would break under their own weight. The brain size has reached its physical limits. Giant insects in horror movies are confined to the realms of science fiction.

The further development of the brain requires the separation of the nerves from the gut. The emergence of vertebrate fish provides the model for the subsequent development of the spinal cord and brain. The skull cavity can house an enlarged brain and the nerves run from the brain through the backbone down the spinal cord. From the eye pits developed an image-forming eye which could present optical patterns to the nervous system. The emergence of amphibians and reptiles on land saw the great development of the fore-brain region which takes place at the expense of the optic lobes.

Twenty years ago Harry Jerison of the University of California developed the idea of the correlation of brain size to body size, and tracked its evolutionary development. He discovered reptiles were small-brained 300 million years ago and remain so today. His graph of reptilian brain size against body size produced a straight line, which includes the dinosaurs. However, the evolution of the early mammals some 200 million years ago marked a leap in relative brain size. These small nocturnal animals were four or five times brainier than the average reptile. This was largely due to the development of the cerebral cortex, which is unique to mammals. This remained the same relative size for some 100 million years. Then, some 65 million years ago, it developed rapidly. According to Roger Lewin, within 30 million years brain development “had increased four to fivefold, with the biggest increases coinciding with the evolution of ungulates (hoofed mammals), carnivores and primates” (New Scientist, 5th December, 1992).

As monkeys, apes and humans evolved, brain size became much bigger. Taking body size into account, monkey's brains are two to three times the average for modern mammals, whereas the human brain is about six times the size. The development of the brain was not of a continuous gradual development but one of fits, starts, and leaps. “Though this broad-brush picture misses important details, the main message is clear enough”, says Roger Lewin, “the brain's history involves long periods of constancy punctuated by bursts of change.”

In under 3 million years — an evolutionary leap — the brain tripled in relative size, producing a cortex that accounts for 70-80 percent of brain volume. The first bipedal hominid species evolved somewhere between 10 and 7 million years ago. However, their brains were relative small, on a par with the ape. Then, about 2.6 million years ago, a rapid expansion took place with the emergence of *Homo*. “A leap in the evolution of the ancestors of modern humans took place,” says geologist Mark Maslin of Kiel University. “What evidence there is,” explains Lewin, “suggests that brain expansion began some 2.5 million years ago,

a period coinciding with the first appearance of stone tools.” With labor, as Engels explained, came the expansion of the brain and the development of speech. Primitive animal communication gave way to language — a qualitative advance. This must have also depended upon the development of vocal cords. The human brain is capable of making abstractions and generalizations beyond that of the chimpanzee, to which we are closely related.

With the increase in brain size came the increase in complexity and the reorganization of neural circuitry. The main beneficiary is the front section of the cortex, the prefrontal zone, which is about six times the size of that in apes. Because of its size, this zone can project more fibers to the midbrain, displacing connections there from other brain regions. “This may be significant for the evolution of language”, says Terrence Deacon of Harvard University, who notes that the prefrontal zone is home to certain human speech centers. For humans, this reality of consciousness is revealed in self-awareness and thought.

Steven Rose observes,

With the emergence of consciousness, a qualitative evolutionary leap forward has occurred, making for the critical distinction between humans and other species, so that humans have become vastly more varied and subject to complex interactions than is possible in other organisms. The emergence of consciousness has qualitatively changed the mode of human existence; with it, a new order of complexity, a higher order of hierarchical organization, becomes apparent. But because we have defined consciousness not as a static form but as a process involving interaction between individual and environment, we can see how, as human relationships have become transformed during the evolution of human society, so human consciousness too has been transformed. Our cranial capacity or cell number may not be so different from the early *Homo sapiens*, but our environments — our forms of society — are very different and hence so too is our consciousness — which also means that so too are our brain states.⁵⁶

Importance of Speech

The impact of speech — especially the development of “inner speech” — on our brain development is of decisive importance. It is not a new idea, but was known to the ancient Greeks and the philosophers of the 17th century, particularly Thomas Hobbes. In *The Descent of Man*, Charles Darwin explained: “A long and complex train of thought can no more be carried on without the aid of words, whether spoken or silent, than a long calculation without the use of figures of algebra.” In the 1930s the Soviet psychologist Lev Vygotsky in the 1930s attempted to reestablish the whole of psychology on this basis.

Using examples of child behavior, he explained why children spend a lot of time talking aloud to themselves. They are rehearsing the habits of planning that they would later internalize as inner speech. Vygotsky showed that this inner speech underpinned the human ability to recollect and recall memories. The human mind is dominated by an inner world of thoughts, stimulated by our sensations, which is capable of generalization and perspective. Animals also have memories, but they seem to be locked into the present, reflecting the immediate environment. The development of human inner speech allows humans to recall and develop ideas. In other words, inner speech played a key role in the evolution of the human mind.

Although Vygotsky's early death cut short his work, his ideas have been taken up and expanded, with an important input from anthropology, sociology, linguistics and educational psychology. In the past, memory was examined as a unitary biological system, containing short and long-term memory. It could be examined neuro-physiologically, biochemically and anatomically. But today a more dialectical approach, involving other sciences, is being pioneered.

"In this reductionist approach", argues Rose, "it follows that the proper task of the sciences of the organism is to collapse the individual's behavior into particular molecular configurations; while the study of populations of organisms comes down to the search for DNA strands which code for reciprocal or selfish altruism. Paradigm cases of this approach over the last decade have been the attempts to purify RNA, protein, or peptide molecules that are produced by learning and which 'code' for specific memories; or the molecular biologist's search for an organism with 'simple' nervous system which can be mapped by serial electron microscope sections and in which the different wiring diagrams associated with different behavioral mutations can be identified."⁵⁷

Rose concludes that "the paradoxes that this type of reductionism gets itself into are probably more vicious than those of the systems modelers. They have been apparent, of course, since Descartes, whose reduction of the organism to an animal machine powered by hydraulics had to be reconciled, for the human, with a free-willed soul in the pineal gland. As then, so today, mechanistic reductionism forces itself into sheer idealism before it is through."

In the brain's evolution few parts are totally discarded. As new structures develop, the old ones are reduced in importance and size. With the development of the brain comes the increased capacity to learn. The transformation from ape to man was originally assumed to have begun with brain development. The size of an ape's brain (by volume) ranges from 400 to 600 cubic centimeters; the

human brain is 1,200 to 1,500 ccs. It was believed the “missing link” would be essentially ape-like, but with a larger brain. Again it was considered that an enlarged brain preceded upright posture.

This first brain theory was decisively challenged by Engels as an extension of the false idealist view of history. The erect posture in walking was the decisive step in the transition from ape to man. It was their bipedal nature that freed their hands, which lead later to the expansion of the brain. “First comes labor,” says Engels, “after it and then side by side with it, articulate speech — these were the two most essential stimuli under the influence of which the brain of the ape gradually changed into that of man.”⁵⁸ Subsequent discovery of fossilized remains confirmed Engels’ view. “The confirmation was complete beyond all scientific doubt. The African creatures being unearthed had brains no larger than those of apes. They had walked and run like humans. The foot differed little from that of modern man, and the hand was halfway to human conformation.”⁵⁹

Despite the growing evidence supporting Engels’ views on human origins, the conception of brain-first development is still alive and kicking today. In a recent book entitled *The Runaway Brain, The Evolution of Human Uniqueness*, the author, Christopher Wills states: “We know that at the same time as our ancestors’ brains were growing larger, their posture was becoming more upright, fine motor skills were developing, and vocal signals were graduating into speech.”⁶⁰

Man becomes increasingly conscious of his environment and himself. Unlike other animals, humans can generalize their experience. Whereas animals are dominated by their environment, humans change their environment to suit their needs. Science has confirmed Engels’ statement that “Our consciousness and thinking, however suprasensuous they may seem, are the product of a material, bodily organ, the brain. Matter is not a product of mind, but mind itself is merely the highest product of matter. This is, of course, pure materialism.”⁶¹ As the brain develops, so does the capacity to learn and generalize. Important information is stored in the brain, probably in many different parts of the system. This information is not erased as the molecules in the brain are renewed. Within fourteen days, 90% of the brain’s proteins are broken down and renewed by identical molecules. Nor is there any reason to believe that the brain has stopped evolving. Its capacity remains infinite. The development of classless society will see a new leap forward in mankind’s understanding. For instance, the advances of genetic engineering are only in their infancy. Science opens up enormous opportunities and challenges. The brain and human intelligence will evolve to

meet these future challenges. But for every problem solved, many more questions will be raised, in an never-ending spiraling of development.

Language and Thought of the Child

There appears to be a certain analogy between the development of human thought in general and the development of the language and thought of the individual human being through childhood and adolescence to adulthood.

This point was made by Engels in *The Part Played by Labor in the Transition of Ape to Man*:

For, just as the developmental history of the human embryo in the mother's womb is only an abbreviated repetition of the history, extending over millions of years, of the bodily evolution of our animal ancestors, beginning from the worm, so the mental development of the human child is only a still more abbreviated repetition of the intellectual development of these same ancestors, at least of the later ones.⁶²

The study of the development from embryo to adult is called ontogeny, whereas the study of evolutionary relationships between species is called phylogeny. Both are strangely linked together, but not as a crude mirror image. For instance, during its development in the womb, the human embryo resembles a fish, an amphibian, a mammal, and appears to pass through phases which recall the stages of animal evolution. All humans are alike in many respects, particularly the substances and structures of the brain. Chemically, anatomically and physiologically there is amazingly little variation. At conception, the fertilized ovum develops into two hollow balls of cells. The first recognized development takes place within eighteen days, as thickening where the balls touch become the neural groove. The forward part enlarges, later to develop into a brain. Other differentiation takes place which will become the eyes, nose and ears. The blood circulation and nervous systems are the first to function in embryo life, with the heart-beat commencing in the third week of conception.

The neural groove becomes a channel and then a tube. In time it will be transformed into the spinal cord. At the head end, swellings appear in the tube to form the forebrain, midbrain and hindbrain. Everything is set for the rapid development of the central nervous system. There is a qualitative leap in the rate of cell division approximating the final cellular structure. By the time the embryo is 13 mm long, the brain has developed into the five-vesicle brain. The stalks that form the optic nerves and eyes emerge. By the end of the third month, the cerebral cortex and cerebellum can be identified, as well as the thalamus and hypothalamus. With the fifth month the wrinkled cortex begins to take shape.

All the essentials are developed by the ninth month, although further development will take place after birth. Even then, the weight of the brain is only about 350 grams, compared with 1,300 to 1,500 grams of an adult. It will be 50% of its adult weight at six months, 60% at a year, and 90% at six years. By the age of ten, it would be 95% of its adult weight. The rapid growth of the brain is reflected in the size of the head. The size of a baby's head is large for its body compared to an adult. The brain of a new born baby is closer than any other organ to its adult state of development. At birth the brain is 10% of the entire body weight compared to only 2% in the adult.

The physical structures of the brain (its biochemistry, cellular architecture and electrical circuitry) are modified by the effects of the brain's response to the environment. Ideas and memories are encoded in the brain in terms of complex changes in the neural system. Thus, all the processes of the brain interact, to give rise to the unique phenomenon of consciousness — matter aware of itself. For Canadian psychologist Donald Hebb, the key lies in the synaptic junctions between two nerve cells, which remains the basis of today's ideas. Particular sets of circuitry and firing patterns between the synapses may encode the memory, but it will not necessarily be localized to a single network of the brain. It can be encoded in both the hemispheres and many times over. The entire scope of the individual's environment, especially in the early years of development, continuously leave unique impressions on the brain processes and behavior. "A variety of the most subtle changes in environment, especially during childhood," says Rose, "can produce long-lasting changes in its chemistry and function."

Without this dialectical interaction between brain and environment, then the individual's development would simply be prescribed by the genetic code. The behavior of individuals would be pre-coded and predictable from the beginning. However, the environment plays a decisive role in development. A changed set of circumstances can bring about a remarkable change in the individual.

Eyes, Hand and Brain

The development of the language and thought of the child was first subjected to a rigorous analysis in the pioneering work of the Swiss epistemologist Jean Piaget. Some aspects of his theories have been questioned, especially the lack of flexibility with which he interpreted the way children move from one to another of his stages. Nevertheless, this was pioneering work,

in a field that had been virtually ignored, and many of his theories retain considerable validity. Piaget was the first one to give an idea of the dialectical process of the development from birth, through childhood to adolescence, as Hegel was the first to provide a systematic exposition of dialectical thinking in general. The defects of both systems should not be allowed to obscure the positive content of their work. Although Piaget's stages are undoubtedly rather schematic, and his research methods open to question, they nevertheless retain value as a general over-view of early human development.

Piaget's theories were a reaction against the views of the behaviorists, whose leading representative, Skinner, was particularly influential in the 1960s in the USA. The behaviorist approach is completely mechanistic, based on a linear pattern of cumulative development. According to this, children learn most efficiently when they are subjected to a linear program of material devised by expert teachers and curriculum planners. Skinner's educational theories fit in very well with the capitalist mentality. Children will only learn, according to this theory, if they are rewarded for doing so, just as a worker who gets extra pay for overtime.

The behaviorists adopted a typically mechanical position on the development of language. Noam Chomsky pointed out that Skinner adequately described how a baby learned the first few words (mainly nouns), but he did not however explain how these were put together. Language is not just a string of words. It is precisely the combination of the words in a certain dynamic relationship that makes language such a rich, effective, flexible and complex instrument. Here, most decidedly, the whole is greater than the sum of the parts. It is really an incredible feat for a child of two to learn the rules of grammar, as any adult who has tried to learn a foreign language will agree.

Compared to this crude and mechanistic dogma, Piaget's theories represented a great step forward. Piaget explained that learning comes naturally to children. It is the job of the teacher to bring out those tendencies which are already present in all children. Moreover, Piaget correctly pointed out that the process of learning is not a straight line, but is punctuated by qualitative breakthroughs. Although Piaget's original stages are open to question, there is no doubt that this dialectical approach, in general, was valid. What was valuable in Piaget's work was that the development of the child was presented as a contradictory process in which each stage was based on the previous one, both overcoming and preserving it. The genetically-conditioned base provides the ready-made material, which from the first moment enters into a dialectical

interaction with the environment. The newborn baby is not conscious, but driven by deep-rooted biological instincts which urgently demand satisfaction. These powerful animal instincts do not disappear, but remain as an unconscious substratum, underlying our activities.

To use the language of Hegel, what we have here is the transition from being-in-itself to being-for-itself — from potential to actual, from an isolated, helpless, unconscious being, a plaything of natural forces to a conscious human being. The movement towards self-consciousness, as Piaget correctly explained, is a struggle, which passes through different phases. The newborn baby does not clearly distinguish itself from its surroundings. Only slowly does it become aware of the distinction between the self and the external world. “The period from birth to the acquisition of language,” writes Piaget, “is marked by an extraordinary mental development.” Elsewhere, he describes the first 18 months of existence as “a Copernican revolution on a small scale.”⁶³ The key to this process is the gradual dawning of the realization of the relation between the subject (self) and the object (reality), which must be understood.

Vygotsky and Piaget

The earliest and best of the critics of Piaget was Vygotsky, the Soviet educationalist who, in the period 1924-34, worked out a consistent alternative to Piaget's ideas. Tragically, Vygotsky's ideas were only published in the Soviet Union after the death of Stalin, and became known in the West in the 1950s and 60s, when they exercised a powerful influence on many, like Jerome Bruner. At the present time, they are widely accepted by educationalists.

Vygotsky was in advance of his time in explaining the important role of gestures in the development of language. This has been revived more recently by psycholinguists unraveling the origins of language. Bruner and others have pointed to the enormous impact of gestures on the later development of language in a child. Whereas Piaget placed more emphasis on the biological aspect of the development of the child, Vygotsky concentrated more on culture, as have people like Bruner. An important part in culture is played by tools, whether they are the sticks and stones of early hominids, or pencils, rubbers and books of today's children.

Recent research has shown that babies are more capable at an earlier stage than Piaget thought. His ideas about very young babies seem to have been overtaken, but much of his research remains valid. Coming from a biological

background, it was inevitable that he should place heavy stress on this aspect of the child's development. Vygotsky approached the question from a different point of view, but nevertheless, there are common points. For example, in his study of the early years of childhood, he deals with "nonlinguistic thought" such as Piaget outlined in his account of "sensorimotor activity," such as using a rake to reach another toy. Alongside this, we notice the incomprehensible sounds of the baby ("baby-talk"). When the two elements combine, there is an explosive development of language. For each new experience, the toddler wants to know the name. While Vygotsky took a different route, the trail was blazed by Piaget.

"The process of growing up is not a linear progression from incompetence to competence: to survive, a newborn baby must be competent at being a newborn baby, not at being a tiny version of the adult it will later become. Development is not just a quantitative process but one in which there are transformations in quality — between suckling and chewing solid food, for instance, or between sensorimotor and cognitive behavior." ⁶⁴

Only gradually, over a long period and by a difficult process of adjustment and learning, does the child cease to be a bundle of blind sensations and appetites, a helpless object, and become a conscious, self-directing free agent. It is this painful struggle to pass from the unconscious to the conscious, from utter dependence on the environment to the domination of the environment, which provides the striking parallel between the development of the individual infant and that of the human species. Of course, it would be wrong to imply that the parallel is a precise one. Every analogy holds good only within definite limits. But it is hard to resist the conclusion that in at least some aspects such parallels do, in fact, exist. From lower to higher; from simple to complex; from unconscious to conscious — such features recur constantly in the evolution of life.

The animals depend more than humans upon the senses, and have better hearing, eyesight and sense of smell. It is noticeable that keenness of eyesight reaches a high point in late childhood, and thereafter diminishes. On the other hand, the higher intellectual functions continue to develop through life, and well into old age. To trace the path whereby humans pass from the unconscious to the level of real consciousness is one of the most fascinating and important tasks in science.

At birth, the baby knows only reflexes. But this does not at all signify passivity. From the very first moment of its existence, the baby's relation with its environment is active and practical. It does not think only with its head, but with its whole body. The development of the brain and consciousness is directly

related to its practical activity. One of the first reflexes is sucking. Even here the process of learning from experience is present. Piaget points out that the baby suckles better after one or two weeks than at first. Later on comes a process of discrimination, where the child begins to recognize things. Later still, the child begins to draw its first generalizations, not only in thought but in action. It does not only suckle at the breast, but also sucks the air, and then his fingers. The Spanish have a saying: "I don't suck my thumb," meaning "I'm not stupid." As a matter of fact, the ability to introduce a thumb into the mouth is quite a difficult task for a baby, which usually appears at about two months, and marks a significant step forward, denoting a certain level of co-ordination of hand and brain.

Immediately after birth the child has difficulty in focusing its attention on particular objects. Gradually, it becomes able to concentrate on specific objects, and anticipates where they are so that it can move its head in order to see them. This development, analyzed by Bruner, takes place during the first two or three months, and involves not only the purely visual field, but also activity — the orientation of the eyes, head, and body towards the object of attention. At the same time, the mouth becomes the link between vision and manual movement. Gradually, it begins a process of visually guided reaching-grasping-retrieving, which always concludes by bringing the hand to the mouth.

For the newborn child, the world is first and foremost something to be sucked. Later, it is something to be looked at and listened to, and, when a sufficient level of co-ordination permits it, something to be manipulated. This is not yet what we could call consciousness, but it is the starting-point of consciousness. A very lengthy process of development is needed for these simple elements to become integrated into habits and organized perceptions. Later on, we get systematic thumb-sucking, the turning of the head to the direction of a sound, following a moving object with the eyes (indicating a level of generalization and anticipation). After five weeks or more, the baby smiles, and recognizes some people rather than others, although this cannot be taken to mean that the baby possesses a notion of a person, or even an object. This is the stage of the most elementary sense-perception.

In its relations to the objective world, the baby has two possibilities: either to incorporate things (and people) into its activities, and thus to assimilate the material world, or to readjust its subjective wishes and impulses to the external world, i.e., to accommodate to reality. From a very early age, the baby tries to "assimilate" the world to itself, by introducing it into its mouth. Later, it learns

to adjust to external reality, gradually begins to distinguish and perceive different objects, and remembers them. It acquires, through experience, the ability to carry out a number of operations, like reaching and grasping. Logical intelligence arises first from concrete operations, from practice, and only much later as abstract deductions.

Piaget identified six clearly defined “stages” in the development of the child. The stage of reflexes, or hereditary functions, including primary instinctive tendencies, such as nutrition. The need to obtain food is a powerful inborn impulse, controlling the reflexes of the newborn child. This is a common feature which humans share with all animals. The newborn child, lacking the elements of higher thought, is nonetheless a natural materialist, who expresses his firm belief in the existence of the physical world in exactly the same way as all animals — by eating it. It takes a great deal of intellectual refinement before clever philosophers succeed in convincing people that we cannot really say whether the material world is out there or not. This supposedly complicated and profound philosophical question is, in fact, resolved by a baby in the only possible way — through practice.

From the age of two, the child enters a period of symbolic thought and preconceptual representation. The child begins to use picture images as symbols to replace the real things. Parallel to this is the development of language. The next stage is conditional representation, recognizing other points of reference in the world, and simultaneously is developed coherent language. This is followed by operational thinking from seven to twelve years of age. The child begins to recognize relationships between objects and to deal with more abstract conceptions.

It is precisely practice, and the interaction of inborn, genetically conditioned tendencies, which provide the key to the mental development of the child. Piaget’s second stage is that of primary motor habits, accompanied by the first “organized perceptions” and primary “differentiated feelings.” The third stage is that of “sensorimotor intelligence” or practice (which is prior to speech). Then comes the phase of “intuitive intelligence” involving spontaneous relations between individuals, especially submission to adults; the phase of “concrete intellectual operations” which includes the development of logic and moral and social feelings (from 7 to 11 or 12 years); and finally, a phase of abstract intellectual operations — the formation of personality and emotional and intellectual integration in adult society (adolescence).

Human progress is closely linked to the development of thought in general, and science and technology in particular. The capacity for rational, abstract thought, does not come easily. Even now, the minds of most people rebel against thought that leaves behind the familiar world of the concrete. This ability appears quite late in the mental development of the child. We see this in children's paintings, which depict what the child actually sees, not what they ought to see, according to the laws of perspective, and so on. Logic, ethics, morality, all appear late in the child's intellectual development. In the first period, every action, every movement, every thought, is the product of necessity. The notion of "free will" has nothing whatever to do with the mental activities of the child. Hunger and fatigue lead to desire for food or sleep, even in the youngest baby.

The possession of a capacity for abstract thought, even on the most primitive level, makes the subject master of the most distant events, both in space and time. This is as true for the child as it was for early humans. Our earliest ancestors did not clearly distinguish themselves from other animals or inanimate nature. Indeed, they had not fully emerged from the animal kingdom, and were very much at the mercy of the forces of nature. The elements of self-awareness seems to exist in chimpanzees, our nearest relatives, though not in monkeys. But only in humans does the potential for abstract thought reach its full expression. This is closely related to language, one of the fundamental distinguishing features of humankind.

The neocortex, which makes up 80% of the volume of the human brain, is the part responsible for relations with groups, and is related to thinking in general. There is a close connection between social life, thought and language. The self-centered nature of the new-born baby gradually gives way to a realization that there is an external world, people and society, with its own laws, demands and restrictions. Quite late on, between three and six months, according to Piaget, the phase of grasping begins, involving first pressure, then manipulation. This is a decisive step, leading to a multiplication of the baby's powers and the formation of new habits. After this, development becomes speeded up. The dialectical nature of the process is indicated by Piaget:

"The point of departure is always a reflex cycle, but a cycle the exercise of which, instead of repeating itself without more ado, incorporates new elements and constitutes with them still wider organized totalities, thanks to progressive differentiations." Thus the development of the child is not a straight line or a

closed circle, but a spiral, where long periods of slow change are interrupted by sudden leaps forward, and each stage involves a qualitative advance.

Piaget's third stage is that of "practical intelligence" or the "sensorimotor stage as such." The exact nature and delineation of these "stages" is, of course, debatable, but the general thrust remains valid. Intelligence is closely related to the manipulation of objects. The development of the brain is directly linked to the hand. As Piaget says: "But it is a question of an exclusively practical intelligence, which is applied to the manipulation of objects, and which, in place of words and concepts, only makes use of perceptions and organized movements in schemes of action."⁶⁵ From this we see that the basis of all human knowledge is experience, activity and practice. The hands, in particular, play a decisive role.

The Emergence of Language

Before speech develops as such, the baby makes use of all kinds of signs, eye contact, cries and other body language, to exteriorize its wants. In the same way, it is clear that before the earliest hominids could speak, they must have used other means to signal to one another. The rudiments of such communication exist in other animals, especially the higher primates, but only in humans does speech exist as such. The long struggle of the child to master speech, with its complex underlying patterns and logic, is synonymous with the acquisition of consciousness. A similar road must have been traversed by early humans.

The throat of the human infant, like that of apes and other mammals, is so constructed that the vocal passage is low down. In this way, it is capable of making the kind of cries that animals make, but not articulate speech. The advantage of this is that it can cry and eat at the same time, without choking. Later on, the vocal passage migrates upwards, reflecting a process that actually occurred during the course of evolution. It is unthinkable that human speech would have arisen all at once, without all kinds of transitional forms. This took place over millions of years, in which there were undoubtedly periods of rapid development, as we see in the development of the human infant.

Can thought exist without language? That depends on what is meant by "thought." The elements of thought exist in animals, especially the higher mammals, who also possess certain means of communication. Among the chimpanzees, the level of communication is quite sophisticated. But in none of these can we speak of either language or thought anything remotely on the human level. The higher develops from the lower, and could not exist without it.

Human speech originates in the incoherent sounds of the baby, but it would be foolish to identify the two. In the same way, it is a mistake to try to show that language existed before the human race.

The same is true of thought. To use a stick to get hold of an object that is out of reach is an act of intelligence. But this appears quite late in the development of the child — about 18 months. This involves the use of a tool (a stick) in a coordinated move, in order to realize a preconceived aim. It is a deliberate, planned action. This kind of activity can be seen among apes, and even monkeys. The use of objects found ready to hand — sticks, stones, etc. — as adjuncts to food-gathering activities is well documented. At twelve months, the child has learnt to experiment by throwing an object in different directions to “see what happens.”

This is a repeated purposeful activity, designed to get results. It implies an awareness of cause and effect (if I do this, then that will happen). None of this knowledge is innate. It is learned through experience. It takes the child 12-18 months to grasp the notion of cause and effect. A most powerful piece of knowledge! It must have taken early humans millions of years to learn the same lesson, which is the real basis of all rational thought and purposeful action. All the more absurd that, at a time when our knowledge of nature has reached such dazzling heights, certain scientists and philosophers should wish to drag thought back to what is really a primitive and childish state, by denying the existence of causality.

In the first two years of life, an intellectual revolution takes place, in which the notions of space, causality and time are formed, not, as Kant imagined, out of thin air, but as a direct result of practice and experience of the physical world. All human knowledge, all the categories of thought, including the most abstract ones, are derived from this. This materialist conception is clearly proven by the development of the child. Initially, the infant does not distinguish between reality and itself. But at a certain point, the realization dawns that what it sees is something outside itself, something which will continue to exist even when it is no longer seen. This is the great breakthrough, the “Copernican revolution” of the intellect. Those philosophers who assert that the material world does not exist, or that this cannot be proven, are, in a literal sense of the word, expressing an infantile idea.

The baby who cries when its mother leaves the room shows that it understands that she has not disappeared just because she is no longer in its field of vision. It cries in the certainty that this action will bring about her return. Up

to the first year, the child believes that what is out of sight has, in effect, ceased to exist. By the end of the second year, it already recognizes cause and effect. Just as there is no Chinese Wall separating thought from action, so there is no absolute dividing-line between the intellectual life of the child and its emotional development. Feelings and thoughts are, in fact, indivisible. They constitute the two complementary aspects of human behavior. Everyone knows that no great enterprise is achieved without the element of the will. Emotions are a most powerful lever for human action and thought, and play a fundamental role in human development. But at every stage, the intellectual development of the child is inextricably bound up with activity. As intelligent behavior emerges, emotional states of mind are associated with actions — cheerfulness or sadness are linked with the success or failure of intentional acts.

The emergence of language represents a profound modification in the behavior and experience of the individual, both from an intellectual and emotional standpoint. It is a qualitative leap. The possession of language creates, to quote Piaget, “the ability to reconstruct his past actions in the form of narration and to anticipate his future actions through verbal representations.” With language, past and future become real for us. We can rise above the restrictions of the present, plan, predict and intervene according to a conscious plan.

Language is a product of social life. Human social activity is unthinkable without language. It must have been present, in one form or another, in the earliest truly human societies, from the very earliest times. Thought itself is a kind of “internal language.” With language comes the possibility of real human social intercourse, the creation of a culture and tradition which can be learned and passed on orally, and later on in writing, as opposed to mere imitation. It also makes possible genuine human relations, where feelings of antipathy, sympathy, love and respect can be expressed in a more coherent, developed way. In embryo, these elements are present from the first six months in the form of imitation. The first words are pronounced, usually isolated nouns. Then the child learns to put two words together. Nouns are gradually connected with verbs and adjectives. Finally, the mastering of grammar and syntax, which entails extremely complex patterns of logical thought. This is a tremendous qualitative leap for every individual as it was for the species.

Very young children can be said to have a “private” language, which is not language in the real sense, but only sounds which represent experiments and attempts to copy adult speech. Articulate speech grows out of these sounds, but

the two must not be confused. Language, by its very nature, is not private, but social. It is inseparable from social life and collective activity, in the first place, co-operation in production, which lies at the basis of all social life from the earliest times. Language represents a colossal leap forward. Once the process started, it would have enormously speeded up the development of consciousness. This can be seen also in the development of the child.

Language represents the beginnings of the socialization of human activity. Before this, early pre-humans must have communicated by other means: cries, body language and other gestures. Indeed, modern humans continue to do so, particularly in moments of great stress or emotion. But the limitations of this kind of “language” are self-evident. They are hopelessly inadequate to convey more than immediate situations. The level of complexity, abstract thought and planning needed for even the simplest human societies based on co-operative production cannot be expressed by such means. Only through language is it possible to escape from the immediate present, recall the past, and foresee the future. Only through language is it possible to establish a really human form of communication with others, to share one’s “inner life” with them. Thus we talk of “dumb animals” as a distinction from humans, the only animals that possess speech.

Socialization of Thought

Through language, the child is initiated into the wealth of human culture. Whereas with other animals, the factor of genetic inheritance is predominant, in human society, the cultural factor is decisive. The human infant has to go through a very long period of “apprenticeship” in which it is completely subordinated to adults, particularly its parents, who, largely by means of language, initiate it into the mysteries of life, society and the world. The child finds itself confronted with a ready-made model to copy and imitate. Later this is expanded to include other adults and children, especially through play. This process of socialization is not easy or automatic, but it is the basis of all intellectual and moral development. All parents have noticed with amusement how small children will withdraw into a world of their own, and quite happily conduct a “conversation” with themselves for long periods, while playing on their own. The development of the child is intimately linked to the process of breaking away from this primitive state of egocentricity, and relating to others and to external reality in general.

In Piaget's original scheme, the period from two to seven years marks the transition from the simply "practical" ("sensorimotor") phase of the intelligence, to thought as such. This process is characterized by all kinds of transitional forms between the two. It reveals itself in play, for example. From seven to twelve, games appear with rules, implying common objectives, as opposed to playing with dolls, say, which is highly individual. The logic of primary infancy can be described as intuition, which is still present in adults — what Hegel calls "immediate" thought. At a later stage, well known to parents, the child begins to ask why? This naïve curiosity is the beginning of rational thinking — the child is no longer willing just to take things as they are, but seeks a rational ground for them. It grasps the fact that all things have a cause, and tries to grasp what this is. It is not satisfied with the mere fact that "B" happens to occur after "A." It wishes to know why it has occurred. Here too the child of between three to seven years of age shows itself to be wiser than some modern philosophers.

Intuition, to which a certain aura of magic and poetry has been traditionally attached, is, in fact, the lowest form of thinking, characteristic of very small children and people on a low level of cultural development. It consists of the immediate impressions provided by the senses, which provoke us to react "spontaneously," that is, in an unthinking way, to a given circumstance. The rigors of logic and consistent thought do not enter into it. Such intuitions can sometimes be spectacularly successful. In such cases, the apparently spontaneous nature of the "flash of inspiration" provides the illusion of a mysterious insight coming "from within" and divinely inspired. In fact, intuition comes, not from the obscure depths of the soul, but from the interiorization of experience, which is obtained, not in a scientific way, but in the form of images and the like.

A person with considerable experience of life can frequently arrive at an accurate assessment of a complicated situation on the basis of the scantiest information. Similarly, a hunter can display almost a "sixth sense" about the animals he is tracking. In the case of truly great minds, flashes of inspiration are considered to represent a quality of genius. In all these cases, what appears to be a spontaneous idea is, in fact, the distilled essence of years of experience and reflection. More often, however, mere intuition leads to a highly unsatisfactory, superficial and distorted form of knowledge. In the case of children, "intuition" marks the primitive, immature phase of thought, before they are able to reason, define and judge. It is so inadequate that it is generally regarded as comical by

adults, who have long since left this phase behind. In all these cases, it goes without saying that there is nothing mystical involved.

In the first stages of life, the child does not distinguish between itself and its physical environment. Only gradually, as we have seen, does the child begin to distinguish between the subject ("I") and the object (the physical world). It begins to understand the real relationship between its environment and itself in practice, through manipulation of objects and other physical operations. The primitive unity is broken down, and a confusing multiplicity of sights, sounds and objects emerges. Only later does the child begin to grasp the connections between things. Experiments have shown that the child is consistently more advanced in deeds than in words.

There is no such thing as a "purely intellectual act." This is particularly clear in the case of small children. It is commonplace to counterpose the heart and the head. This, too, is a false opposition. The emotions play a part in the solution of intellectual problems. Scientists become excited over the solution of the most abstruse equations. Different schools of thought clash heatedly over problems of philosophy, art, and so on. On the other hand, there is no such thing as pure acts of affection. Love, for example, presupposes a high degree of understanding between two people. Both the intellect and the emotions play a role. The one presupposes the other, and they intervene and condition each other, to a greater or lesser degree.

As the degree of socialization advances and develops, the child becomes more aware of the need for what Piaget calls "inter-personal sentiments" — the emotional relations between people. Here we see that the social bond itself involves contradictory elements of attraction and repulsion. The child learns this first in relation to its parents and family, and then forms close bonds with broader social groups. Feelings of sympathy and antipathy are developed, linked to the socialization of actions, and the appearance of moral sentiments — good and bad, right and wrong, which mean much more than "I like" or "I dislike." They are not subjective but objective criteria derived from society.

These powerful bonds are an important part of the evolution of human society, which, from the outset was based on co-operative social production and mutual dependence. Without this, humanity would have never emerged from the animal world. Morality and tradition are learned through language, and passed on from generation to generation. Compared to this, the factor of biological inheritance appears quite secondary, although it remains the raw material from which humanity is constructed.

With the commencement of proper schooling, from about the age of seven, the child begins to develop a strong sense of socialization and co-operation. This is shown in games with rules — even a game of marbles requires a knowledge and acceptance of quite complicated rules. Like the rules of ethics and the laws of society, they must be accepted by all, in order to be viable. A knowledge of rules and how they are to be applied goes together with a grasp of something as complicated as the grammatical and syntactical structure of language.

Piaget makes the important observation that “all human behavior is at the same time social and individual.” Here we have a most important example of the unity of opposites. It is entirely false to counterpose thought to being, or individual to society. They are inseparable. In the relationship between subject and object, between the individual and the environment (society) the mediating factor is human practical activity (labor). The communication of thought is language (exteriorized reflection). On the other hand, thought itself is interiorized social intercourse. At seven years of age, the child begins to understand logic, which consists precisely of a system of relations, permitting the coordination of points of view.

In a brilliant passage, Piaget compares this stage with the early stage of Greek philosophy, when the Ionian materialists parted company with mythology, in order to arrive at a rational understanding of the world:

“It is surprising to observe that, among the firsts (new forms of explanation of the unities) to appear, there are some which present a notable similarity to that given by the Greeks precisely in the epoch of decline of mythological explanations, properly so-called.”

Here we see, in a very striking way, how the forms of thought of each individual child in its early development, provides a rough parallel to the development of human thought in general. In the early stages, there are parallels with primitive animism, where the child thinks that the sun shines, because it was born. Later the child imagines that clouds come from smoke, or air; stones are made of earth, etc. This recalls the early attempts to explain the nature of matter in terms of water, air, and so on. The great significance of this is that it was a naïve attempt to explain the universe in materialist, scientific terms, rather than in terms of religion and magic. The child of seven begins to grasp the notion of time, space, speed, etc. However, this takes time. Contrary to Kant’s theory that the notion of time and space are inborn, the child cannot grasp such abstract ideas until they are experimentally demonstrated. Thus, idealism is

shown to be false by a study of the processes of developing of human thought itself.

14. MARXISM AND DARWINISM

Darwin's Gradualism

"It is sometimes said that the standpoint of dialectics is identical with that of evolution. There can be no doubt that these two methods have points of contact. Nevertheless, between them there is a profound and important difference which, it must be admitted, is far from favoring the teaching of evolution. Modern evolutionists introduce a considerable admixture of conservatism into their teaching. They want to prove that there are no leaps either in nature or in history. Dialectics, on the other hand, knows full well that in nature and also in human thought and history leaps are inevitable. But it does not overlook the undeniable fact that the same uninterrupted process is at work in all phases of change. It only endeavors to make clear to itself the series of conditions under which gradual change must necessarily lead to a leap." (Plekhanov) ⁶⁶

Darwin regarded the pace of evolution as a gradual process of orderly steps. It proceeded at a constant rate. He adhered to Linnaeus' motto: "Nature does not make leaps." This conception was reflected elsewhere in the scientific world, most notably with Darwin's disciple, Charles Lyell, the apostle of gradualism in the field of geology. Darwin was so committed to gradualism, that he built his whole theory on it. "The geological record is extremely imperfect," stated Darwin, "and this fact will to a large extent explain why we do not find interminable varieties, connecting together all the extinct and existing forms of life by the finest graduated steps. He who rejects these views on the nature of the geological record, will rightly reject my whole theory." This Darwinism gradualism was rooted in the philosophical views of Victorian society. From this 'evolution' all the leaps, abrupt changes and revolutionary transformations are eliminated. This anti-dialectical outlook has held sway over the sciences to this present day. "A deeply rooted bias of Western thought predisposes us to look for continuity and gradual change," says Gould.

However, these views have given rise to a heated controversy. The present fossil record is full of gaps. It reveals long term trends, but they are also very jerky. Darwin believed that these jerks were due to the gaps in the record. Once the missing pieces were discovered, it would reveal a gradual smooth evolution of the natural world. Or would it? Against the gradualist approach, paleontologists Niles Eldredge and Stephen Jay Gould have put forward a theory of

evolution called punctuated equilibria, suggesting that the fossil record is not as incomplete as had been thought. The gaps could reflect what really occurred. That evolution proceeds with leaps and jumps, punctuated with long periods of steady, gradual development.

"The history of life is not a continuum of development, but a record punctuated by brief, sometimes geologically instantaneous, episodes of mass extinction and subsequent diversification," says Gould. Rather than a gradual transition, "modern multicellular animals make their first uncontested appearance in the fossil record some 570 million years ago — and with a bang, not a protracted crescendo. This 'Cambrian explosion' marks the advent (at least into direct evidence) of virtually all major groups of modern animals — and all within the minuscule span, geologically speaking, of a few million years." ⁶⁷

Gould also points to the feature that the boundaries of geological time coincide with turning points in the evolution of life. This conception of evolution comes very close to the Marxist view. Evolution is not some smooth, gradual movement from lower to higher. Evolution takes place through accumulated changes which burst through in a qualitative change, through revolutions and transformations. Almost a century ago, the Marxist George Plekhanov polemicized against the gradual conception of evolution:

"German idealist philosophy," he noted, "decisively revolted against such a misshapen conception of evolution. Hegel bitinglly ridiculed it, and demonstrated irrefutably that both in nature and in human society leaps constituted just as essential a stage of evolution as gradual quantitative changes. 'Changes in being,' he says, 'consists not only in the fact that one quantity passes into another quantity, but also that quality passes into quality, and vice versa. Each transition of the latter kind represents an interruption in gradualness, and gives the phenomenon a new aspect, qualitatively distinct from the previous one.'" ⁶⁸

"Evolution" and "revolution" are two sides of the same process. In rejecting gradualism, Gould and Eldredge have sought an alternative explanation of evolution, and have been influenced by dialectical materialism. Gould's paper on "Punctuated Equilibria" draws parallels with the materialist conception of history. Natural selection theory is a good explanation of how species get better at doing what they do, but provides an unsatisfactory explanation for the formation of new species. The fossil record shows six major mass extinctions took place at the beginning and end of the Cambrian period (600 million and 500 million years ago respectively), and the ends of the Devonian (345 million years

ago), the Permian (225 million), the Triassic (180 million) and the Cretaceous (63 million). A qualitatively new approach is needed to explain this phenomenon.

The evolution of a new species is marked by the evolution of a genetic make-up that allows members of the new species to breed with each other, but not with members of other species. New species arise from a branching off from ancestral stocks. That is, as Darwin explained, one species descended from another species. The tree of life shows that more than one species can be traced back to one ancestral stock. Humans and chimpanzees are different species, but had one common extinct ancestor. Change from one species into another takes place rapidly between two stable species. This transformation does not take place in one generation or two, but over possibly hundreds of thousands of years. As Gould comments: "This may seem like a long time in the framework of our lives, but it is a geological instant...If species arise in hundreds or thousands of years and then persist, largely unchanged, for several million, the period of their origin is a tiny fraction of one percent of their total duration."

The key to this change lies in geographical separation, where a small population has become separated from the main population at its periphery. This form of speciation, called *allopatric*, allows a rapid evolution to take place. As soon as an ancestral species is separated, the inter-breeding stops. Any genetic changes build up separately. However, in the smaller population, genetic variations can spread very quickly in comparison to the ancestral group. This can be brought about by natural selection responding to changing climatic and geographical factors. As the two populations diverge, they eventually reach a point where two species are formed. Quantitative changes have given rise to a qualitative transformation. If they ever meet in the future, then so genetically divergent are they that they are unable to breed successfully; either their offspring will be sickly or sterile. Eventually, similar species with the same way of life, would tend to compete, leading eventually to the extinction of the least successful.

As Engels commented: "The organic process of development, both of the individual and of species, by differentiation, is the most striking test of rational dialectics." Again, "The further physiology develops, the more important for it becomes these incessant, infinitely small changes, and hence the more important for it also the consideration of differences within identity, and the old abstract standpoint of formal identity, that an organic being is to be treated as something simply identical with itself, as something constant, becomes out of date." Engels

then concludes: "If there the individuals which become adapted survive and develop into a new species by continually increasing adaption, while the other more stable individuals die away and finally die out, and with them the imperfect intermediate stages, then this can and does proceed without any Malthusianism, and if the latter should occur at all it makes no change to the process, at most it can accelerate it." ⁶⁹

Gould correctly says that the theory of punctuated equilibria is not in contradiction to the main tenet of Darwinism, natural selection, but, on the contrary, enriches and strengthens Darwinism. Richard Dawkins in his book *The Blind Watchmaker* attempts to down-grade Gould and Eldredge's recognition of dialectical change in nature. He sees little difference between "real" Darwinian gradualism and "punctuated equilibria." He states: "The theory of punctuated equilibrium is a gradualist theory, albeit it emphasizes long periods of stasis intervening between relatively short bursts of gradualistic evolution. Gould has misled himself by his own rhetorical emphasis..." Dawkins then concludes, "in reality, all are 'gradualists.'"

Dawkins criticizes the punctuationists for attacking and misrepresenting Darwin. He says we need to see Darwin's gradualism in its context — as an attack on creationism. "Punctuationists, then, are really just as gradualist as Darwin or any other Darwinian; they just insert long periods of stasis between spurts of gradual evolution." But this is not a secondary difference, it is the essence of the matter. To criticize the weakness of Darwinism is not to undermine its unique contribution, but to synthesize it with an understanding of real change. Only then can Darwin's historic contribution be fully rounded out as an explanation of natural evolution. As Gould correctly says, "The modern theory of evolution does not require gradual change. In fact, the operation of Darwinian processes should yield what we see in the fossil record. It is gradualism that we must reject, not Darwinism." ⁷⁰

No Progress?

The fundamental thrust of Gould's argument is undoubtedly correct. What is more problematical is his idea that evolution does not travel an inherently progressive path:

"Increasing diversity and multiple transitions seem to reflect a determined and inexorable progression toward higher things," states Gould. "But the paleontological record supports no such interpretation. There has been no steady

progress in the higher development of organic design. For the first two thirds to five-sixths of life's history, monerans alone inhabited the earth, and we detect no steady progress from 'lower' to 'higher' prokaryotes. Likewise, there has been no addition of basic designs since the Cambrian explosion filled our biosphere (although we can argue for limited improvement within a few designs — vertebrates and vascular plants, for example).”⁷¹

Gould argues, particularly in his book, *Wonderful Life*, that the number of animal phyla (basic body plans) was greater soon after the “Cambrian explosion” than today. He says diversity has not increased and there are no long-term trends in evolution, and the evolution of intelligent life is accidental.

Here it seems to us that Eric Lerner's criticisms of Gould are correct:

Not only is there a huge difference between the contingencies that lead to the evolution of a particular species and a long-term trend in evolution, such as towards greater adaptability or intelligence, but Gould rests his case on facts that are an example of just such a trend!” says Lerner. “Over time, evolution has tended to concentrate more and more on specific modes of development. Nearly all chemical elements were in existence ten billion years ago or more. The types of compounds vital to life — DNA, RNA, proteins, and so on — were all present on earth some four billion years ago. The main kingdoms of life — animals, plants, fungi, and bacteria — have existed for two billion years; there have been no new ones in that time. As Gould shows, the main phyla have existed for six hundred million years, and the major orders (a lower grouping) for about four hundred million years.

As evolution has sped up, it has become more and more specific, and the earth has been transformed by the social evolution of a single species, our own. This is exactly the sort of long-term trend that Gould, despite his great contribution to evolutionary theory, is ideologically determined to ignore. Yet it exists, as does the trend towards intelligence.”⁷²

The fact that evolution has resulted in greater complexity, from lower organisms to higher ones, leading to human beings with large brains capable of the most complex tasks, is proof of its progressive character. That does not mean that evolution takes place in a straight ascending line, as Gould correctly argues; there are breaks, retrogressions, and pauses within the general progress of evolution. Although natural selection takes place in response to environmental changes (even of a local character), it nevertheless has led to greater complexity of life forms. Certain species have adapted to their environment and have existed in that form for millions of years. Other species have become extinct having lost out in competition with other more advanced models. That is the evidence of the evolution of life over the past 3.5 billion years.

The reason for Gould's emphatic rejection of the notion of progress in evolution has more to do with social and political reasons than strictly scientific ones. He knows that the idea of evolutionary progress and "higher species" have been systematically misused in the past in order to justify racism and imperialism — the alleged superiority of the white man was supposed to give the nations of Europe the right to seize the land and wealth of the "lesser breeds without the law" in Africa and Asia. As late as the 1940s respectable men of science were still publishing "evolutionary trees" showing the white man on top, with the black and other "races" on separate and lower branches, a little higher than the gorillas and chimpanzees. When questioned about his rejection of the notion of progress in evolution as "noxious," Gould justified himself as follows:

"'Progress is not intrinsically and logically noxious,' he replied. 'It's noxious in the context of Western cultural traditions.' With roots going back to the seventeenth century, progress as a central social ethic reached its height in the nineteenth century, with the industrial revolution and Victorian expansionism, Steve explained. Fears of self-destruction in recent decades, either militarily inflicted or through pollution, have dulled the eternal optimism of the Victorian and Edwardian eras. Nevertheless, the assumed inexorable march of scientific discovery and economic growth continue to fuel the idea that progress is a good and natural part of history. 'Progress has been a prevailing doctrine in the interpretation of historical sequence,' Steve continued, 'and since evolution is the grandest history of all, the notion of progress immediately got transferred to it. You are aware of some of the consequences of that.'" ⁷³

One can sympathize with Gould's reaction to such ignorant and reactionary rubbish. It is also true that terms like "progress" may not be ideal from a strictly scientific point of view when applied to evolution. There is always the risk that it could imply a teleological approach, that is, the conception of nature as operating according to a pre-established plan, worked out by a Creator. However, as usual, the reaction has swung too far the other way. If the word progress is inadequate, it could be substituted by, say, complexity. Can it be denied that there has been real development in living organisms since the first single-celled animals until now?

There is no need to return to the old one-sided view of Man, the culminating point of evolution, in order to accept that the past 3.5 billion years of evolution has not just meant change, but actual development, passing from simpler forms to more complex living systems. The fossil record bears witness to this. For example, the dramatic increase in average brain size with the evolution

of mammals from reptiles, some 230 million years ago. Similarly, there was a qualitative leap in brain size with the emergence of humans, and this, in turn, did not take place as a smooth quantitative process, but as a series of leaps, with *Homo habilis*, *Homo erectus*, *Homo neanderthalis*, and finally *Homo sapiens*, representing decisive turning points.

There is no reason to suppose that evolution has reached its limit, or that human beings will experience no further development. The process of evolution will continue, although it will not necessarily take the same form as in the past. Profound changes in the social environment, including genetic engineering, can modify the process of natural selection, giving human beings for the first time the possibility of determining their own evolution, at least to some degree. This will open up an entirely new chapter in human development, especially in a society guided by the free and conscious decisions of men and women, and not the blind play of market forces and the animal struggle for survival.

Marxism and Darwinism

“The kinds of values upheld in Marxist doctrine are almost diametric opposites from those which emerge from a scientific approach on our present terms.” (Roger Sperry, winner of the 1981 Nobel Prize for Medicine.)

“The church takes her stand against the inroads of chaos and the twentieth century gods of Progress and a materialistic world-view...Genesis then rings true as ever, whether one follows an evolutionary account of biological origins or not.” (Blackmore and Page, *Evolution: the Great Debate*)

Using the method of dialectical materialism, Marx and Engels were able to discover the laws that govern history and the development of society in general. Unconsciously using a similar method, Charles Darwin was able to uncover the laws of evolution of plants and animals. “Darwin applied a consistent philosophy of materialism to his interpretation of nature,” states paleontologist Stephen Jay Gould. “Matter is the ground of all existence; mind, spirit, and God as well, are just words that express the wondrous results of neuronal complexity.”

Charles Darwin’s theory of evolution revolutionized our outlook on the natural world. Before him, the prevailing view amongst scientists was that species were immutable, having been created by God for specific functions in nature. Some accepted the idea of evolution, but in a mystical form, directed by vital forces which left room for the decisive intervention of the Supreme Being. Darwin represents a decisive break with this idealist outlook. For the first time,

primarily though not exclusively through a process of natural selection, evolution provided an explanation of how species have changed over billions of years, from the simplest forms of unicellular organisms to the most complex forms of animal life, including ourselves. Darwin's revolutionary contribution was to discover the mechanism that brought about change, thereby putting evolution on a firm scientific basis.

There is a rough analogy here with the role played by Marx and Engels in the field of the social sciences. Long before them, others had recognized the existence of the class struggle. But not until Marx's analysis of the Labor Theory of Value and the development of historical materialism, was it possible to provide this phenomenon with a scientific explanation. Marx and Engels gave enthusiastic support to Darwin's theory which provided confirmation for their ideas, as applied to nature. On 16th January, 1861, Marx wrote to Lassalle: "Darwin's book is very important and serves me as a natural scientific basis for the class struggle in history. One has to put up with the crude English method of development, of course. Despite all deficiencies, not only is the death-blow dealt here for the first time to 'teleology' in the natural sciences but its rational meaning is empirically explained."

Darwin's *Origin of Species* appeared in 1859, the same year that Marx published his *Preface to the Critique of Political Economy*, which fully rounded out the materialist conception of history. Darwin had worked out the theory of natural selection more than twenty years earlier, but refrained from publication for fear of the reaction to his materialist views. Even then, he only referred to human origins with the phrase "light will be thrown on the origin of man and his history." Only when he could not hide them any longer was *The Descent of Man* published in 1871. Such were its disquieting ideas, Darwin was rebuked for publishing "at a moment when the sky of Paris was red with the incendiary flames of the Commune." He studiously avoided the question of religion, although he clearly had rejected Creationism. In 1880, he wrote: "It seems to me (rightly or wrongly) that direct arguments against Christianity and Theism hardly have any effect on the public; and that freedom of thought will best be promoted by that gradual enlightening of human understanding which follows the progress of science. I have therefore always avoided writing about religion and have confined myself to science."

Darwin's materialist conception of nature was a revolutionary breakthrough in providing a scientific conception of evolution. However, Marx was by no means uncritical of Darwin. In particular, he criticized his "crude English

method” and showed how Darwin’s deficiencies were based upon the influences of Adam Smith and Malthus. Lacking a definite philosophical standpoint, Darwin inevitably fell under the influence of the prevailing ideology of the times. The Victorian English middle class prided themselves on being practical men and women, with a gift for making money and “getting on in life.” The “survival of the fittest,” as a description of natural selection, was not originally used by Darwin, but by Herbert Spencer in 1864. Darwin was not concerned with progress in Spencer’s sense — human progress based on the elimination of the “unfit” — and was unwise to adopt his phrase. Likewise, the phrase “struggle for existence” was used by Darwin as a metaphor, but it was distorted by conservatives, who used Darwin’s theories for their own end. To Social Darwinists, the most popular catchwords of the Darwinian “survival of the fittest” and “struggle for existence”, when applied to society suggested that nature would ensure the best competitors in a competitive situation would win, and that this process would lead to continuing improvement. It followed from this that all attempts to reform social processes were efforts to remedy the irremediable, and that, as they interfered with the wisdom of nature, they could lead only to degeneration. As Dobzhansky put it:

“Since Nature is ‘red in tooth and claw,’ it would be a big mistake to let our sentiments interfere with Nature’s intentions by helping the poor, the weak, and the generally unfit to the point where they will be as comfortable as the rich, the strong, and the fit. In the long run, letting Nature reign will bring the greatest benefits. ‘Pervading all Nature we may see at work a stern discipline which is a little cruel that it may be very kind,’ wrote Herbert Spencer.”⁷⁴

Darwin and Malthus

“Population, when unchecked, increases in a geometrical ratio. Subsistence only increases in an arithmetical ratio.” (Thomas Robert Malthus, *The Principle of Population*)

The laissez-faire economics of Adam Smith may have given Darwin an insight into natural selection, but as Engels remarked: “Darwin did not know what a bitter satire he wrote on mankind, and especially on his countrymen, when he showed that free competition, the struggle for existence, which the economists celebrate as the highest historical achievement, is the normal state of the Animal Kingdom.”⁷⁵ Darwin was inspired by Malthus’s *Essay on Population* written in 1798. This theory purports to show that population grows geomet-

rically and food supplies only arithmetically, unless checked by famine, war, disease, or restraint. It was shown to be false.

Unlike Spencer, Darwin understood “fitness” in relation only to a given environment, not to an absolute scale of perfection. In fact, neither of the two terms with which Darwin’s name is chiefly associated, “evolution” and “survival of the fittest,” occurs in early editions of *The Origins*, where his key ideas are expressed by the words “mutability” and “natural selection.” On the 18th June 1862, Marx wrote to Engels: “Darwin, whom I have looked up again, amuses me when he says he is applying the ‘Malthusian’ theory also to plants and animals, as if with Mr. Malthus the whole point were not that he does not apply the theory to plants and animals but only to human beings — and with geometrical progression — as opposed to plants and animals.” Engels also rejected Darwin’s crude description or jargon, and says: “Darwin’s mistake lies precisely in lumping together in ‘natural selection’ or the ‘survival of the fittest’, two absolutely separate things:

“1. Selection by the pressure of over-population, where perhaps the strongest survive in the first place, but where the weakest in many respects can also do so.

“2. Selection by greater capacity of adaption to altered circumstances, where the survivors are better suited to these circumstances, but where this adaption as a whole can mean regress just as well as progress (for adaption to parasitic life is always regress).

“The main thing: that each advance in organic evolution is at the same time a regression, fixing one-sided evolution and excluding evolution along many other directions. This, however, (is) a basic law.”⁷⁶

Clearly, there exists a struggle for survival — though not in the Spencerian sense — in nature where scarcity exists, or danger to the members of a species through predators. “However great the blunder made by Darwin in accepting the Malthusian theory so naively and uncritically,” says Engels, “nevertheless anyone can see at the first glance that no Malthusian spectacles are required to perceive the struggle for existence in nature — the contradiction between the countless host of germs which nature so lavishly produces and the small number of those which ever reach maturity, a contradiction which in fact for the most part finds its solution in a struggle for existence — often of extreme cruelty.”⁷⁷

Many species produce vast numbers of seeds or eggs to maximize their survival rate, particularly in the early years of life. On the other hand, the human species has survived in other ways, as its development is very slow, and where a

great deal of energy and effort is invested in raising very few, late maturing offspring. Our advantage lies within our brain, and its capacity for learning and generalization. Our population growth is not controlled by the death of large numbers of our offspring, and so cannot be compared crudely to other species.

History itself provides the final answer to Malthus. A. N. Whitehead has pointed out that from the tenth to the 20th century, a continually rising population in Europe was accompanied by generally rising living standards. This cannot be squared with the Malthusian theory, even if the question of “checks” is introduced, a means of “delaying the inevitable outcome.” A thousand years should be sufficient to demonstrate the correctness or otherwise of any theory. “The plain truth,” as Whitehead says, “is that during this period and over that area (i.e., Europe) the so-called checks were such that the Malthusian Law represented a possibility, unrealized and of no importance.”⁷⁸

Whitehead points out that the alleged “checks” were not even in proportion to the density of the population. For example, the plagues were mainly the result, not of population size, but of bad sanitation. Not birth control, but soap, water, and proper drains would have been the remedy. The Thirty Years War cut the population of Germany by half — quite a drastic “check” on population growth. The war had several causes, but excessive population has never been mentioned as one of them. Nor, to the best of our knowledge, has it played a noticeable role in any of the other wars in which European history is so rich. For example, the peasant uprisings at the end of the Middle Ages in France, Germany and England were not caused by excess population. As a matter of fact, they occurred precisely at a time when the population had been decimated by the Black Death. At the beginning of the 16th century, Flanders was thickly populated, yet enjoyed far higher living standards than Germany, where the grinding poverty of the peasants contributed to the Peasants’ War.

Malthus’ theories are worthless from a scientific point of view but have consistently served as an excuse for the most inhuman application of so-called market policies. In the Irish potato famine of the 1840s, as a result of which the population of Ireland was reduced from over 8 million to 4.5 million, the English landlords in Ireland continued to export wheat. Following sound free market principles, the “Liberal” government in London refused to introduce any measure which might interfere with free trade or prices, and cancelled the supply of cheap maize to the Irish, therefore condemning millions to death by starvation. The Malthusian principles of the English government were defended by Charles Grenville, secretary to the Privy Council thus:

"...The state of Ireland is to the last degree deplorable, and enough to induce despair: such general disorganization and demoralization, a people with rare exceptions besotted with obstinacy and indolence, reckless and savage — all from high to low intent on doing as little and getting as much as they can, unwilling to rouse and exert themselves, looking to this country for succor, and snarling at the succor which they get; the masses brutal, deceitful and idle, the whole state of things contradictory and paradoxical. While menaced with the continuance of famine next year, they will not cultivate the ground, and it lies unsown and untilled. There is no doubt that the people never were so well off on the whole as they have been this year of famine. Nobody will pay rent, and the savings banks are overflowing. With the money they get from our relief funds they buy arms instead of food, and then shoot the officers who are sent over to regulate the distribution of relief. While they crowd to the overseers with demands for employment, the landowners cannot produce hands, and sturdy beggars calling themselves destitute are apprehended with large sums in their pockets. 28th November, 1846."

The real state of affairs was described by Doctor Burritt, who was horrified to see men working on roads with their limbs swollen to almost twice their normal size. The body of a twelve year old boy was "swollen to nearly three times its usual size and had burst the ragged garment which covered him." Near a place called Skull, "we passed a crowd of 500 people, half naked and starving. They were waiting for soup to be distributed amongst them. They were pointed out to us, and as I stood looking with pity and wonder at so miserable a scene, my conductor, a gentleman residing at East Skull and a medical man, said to me: 'Not a single one of those you now see will be alive in three weeks: it is impossible.'...The deaths here average 40 to 50 daily. Twenty bodies were fortunate in getting buried at all. The people build themselves up in their cabins, so that they may die together with their children and not be seen by passers-by."

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There was no more reason for these people to die of hunger than it is for millions to starve today, while farmers are paid not to grow food in the European Union and USA. They are not victims of the laws of nature, but of the laws of the market.

From the beginning, Marx and Engels denounced the false theories of Malthusianism. Answering the arguments of "Parson Malthus," in a letter to Lange dated 29th March 1865 Engels wrote: "The pressure of population is not upon the means of subsistence but upon the means of employment; mankind

could multiply more rapidly than modern bourgeois society can demand. To us a further reason for declaring this bourgeois society a barrier to development which must fall.”

The introduction of machinery, new scientific techniques and fertilizers means that world food production can easily keep abreast of population growth. The spectacular growth in the productivity of agriculture is taking place when the proportion of the population involved in it continues to fall. The extension of the agricultural efficiency already attained in the advanced countries to the entire farming world would yield a huge increase in production. Only a very small part of the vast biological productivity of the ocean is used at present. Hunger and starvation exist mainly due to the destruction of food surpluses to keep up the price of food and the need to maintain the profit levels of the agro-monopolies.

The widespread hunger in the so-called Third World is not the product of “natural selection,” but very definitely a man-made problem. Not the “survival of the fittest,” but greed for profits of a handful of big banks and monopolies is what condemns millions to a life of desperate poverty and actual starvation. Just to pay back the interest on their accumulated debts, the poorest countries are compelled to grow cash crops for export, including rice, cocoa and other food, which could be used to feed their own people. In 1989, Sudan was still exporting food, while its people starved to death. In Brazil, it is estimated that about 400,000 children die of hunger every year. Yet Brazil is one of the biggest exporters of food. The same discredited ideas continue to re-surface from time to time, as an attempt is made to blame the nightmare conditions of the Third World on the fact that there are “too many people” (meaning black, yellow and brown people). The fact that, in the absence of pensions, poor peasants need to have as many children as possible (especially sons) to keep them in old age, is conveniently ignored. Poverty and ignorance causes the so-called “population problem.” As living standards and education increase, the growth in population tends to fall automatically. Meanwhile, the potential for increased food production is immense, and is being held down artificially in order to boost the profits of a few wealthy farmers in Europe, Japan and the USA. The scandal of mass starvation in the late 20th century is even more repugnant because it is unnecessary.

Social Darwinism

Although they greatly admired Darwin, Marx and Engels were by no means uncritical of his theories. Engels understood that Darwin's ideas would be later refined and developed — a fact confirmed by the development of genetics. He wrote to Lavrov in November 1875: "Of the Darwinian doctrine I accept the theory of evolution, but Darwin's method of proof (struggle for life, natural selection) I consider only a first, provisional, imperfect expression of a newly discovered fact." And again in his book *Anti-Dühring*: "The theory of evolution itself is however still in a very early stage, and it therefore cannot be doubted that further research will greatly modify our present conceptions, including strictly Darwinian ones, of the process of the evolution of species."

Engels sharply criticized Darwin's one-sidedness as well as the Social Darwinism that was to follow. "Hardly was Darwin recognized," states Engels, "before these same people saw everywhere nothing but struggle. Both views are justified within narrow limits, but both are equally one-sided and prejudiced...Hence, even in regard to nature, it is not permissible one-sidedly to inscribe only 'struggle' on one's banners. But it is absolutely childish to desire to sum up the whole manifold wealth of historical evolution and complexity in the meager and one-sided phrase 'struggle for life.' That says less than nothing." He then goes on to explain the roots of this error: "The whole Darwinian theory of the struggle for life is simply the transference from society to organic nature of Hobbes' theory of *Bellum Omnium Contra Omnes* (the war of each against all — ed.), and of the bourgeois economic theory of competition, as well as the Malthusian theory of population. When once this feat has been accomplished (the unconditional justification for which, especially as regards the Malthusian theory, is still very questionable), it is very easy to transfer these theories back again from natural history to the history of society, and altogether too naïve to maintain that thereby these assertions have been proved as eternal natural laws of society."⁸⁰

The Social Darwinian's parallels with the animal world fitted in with the prevailing racist arguments that human character was based upon the measurement of men's skulls. For D. G. Brinton, "the European or white race stands at the head of the list, the African or Negro at its foot" (1890). Cesare Lombroso, an Italian physician, in 1876, argued that born criminals were essentially apes, a throw-back in evolution. It was part of the desire to explain human behavior in terms of innate biology — a tendency which can still be

observed today. The 'struggle for survival' was seen as innate in all animals including man, and served to justify war, conquest, profiteering, imperialism, racialism, as well as the class structure of capitalism. It is the fore runner of the cruder varieties of sociobiology and the theories of the *Naked Ape*. After all, was it not W. S. Gilbert whose satire proclaimed:

*Darwinian Man, though well-behaved,
At best is only a monkey shaved!*

Darwin stressed that "Natural Selection has been the most, but not the exclusive, means of modification." He explained that the adaptive changes in one part can lead to modifications of other features that have no bearing on survival. However, as opposed to the idealist conception of life, epitomized by the Creationists, the Darwinians scientifically explained how life evolved on the planet. It was a natural process which can be explained by the laws of biology, and the interaction of organisms with their environment. Independently of Darwin, another naturalist, Alfred Russel Wallace, had also constructed the theory of natural selection. This prompted Darwin to go into print after more than twenty years delay. However, an essential difference between Darwin and Wallace, was that Wallace believed all evolutionary change or modification to be determined solely by natural selection. But the rigid hyper-selectionist Wallace would end up rejecting natural selection when it concerned the brain and intellect, concluding that God had intervened to construct this unique creation!

Darwin explained that the evolution of life, with its rich and varied forms, was an inevitable consequence of the reproduction of life itself. Firstly, like breeds like, with minor variations. But secondly, all organisms tend to produce more offspring than survive and breed. Those offspring which have the greatest chance of survival are those more equipped to adapt to their surroundings, and, in turn, their offspring will tend to be more like them. The characteristics of these populations will, over time, increasingly adapt to their environment. In other words, the "fittest" survive and spread their favored characteristics through populations. In nature, Darwinian evolution is a response to changing environments. Nature "selects" organisms with characteristics best able to adapt to its surroundings. "Evolution by natural selection," says Gould, "is no more than a tracking of these changing environments by differential preservation of organisms better designed to live in them." Thus, natural selection directs the course of evolutionary change. This discovery by Darwin was described by Leon

Trotsky as “the highest triumph of the dialectic in the whole field of organic matter.”

15. THE SELFISH GENE?

Genetics

It was not until the late 1930s that Darwin’s mechanism for evolution — natural selection — obtained widespread acceptance. At this time, leading scientific figures like Fisher, Haldane, and Wright became the founding fathers of neo-Darwinism, which fused natural selection with Mendelian genetics. The theory of heredity was essential for the connection between the theory of evolution and cell theory. In the 19th century, biologists Schleiden, Schwann, and Virchow explained that cells were the basic unit of all living things. In 1944, Oswald Avery identified DNA in the cell nucleus as the material forming the basis of heredity. The discovery of Crick and Watson of the double helix of DNA further clarified the pathway of evolution. Darwin’s variations in offspring were due to changes in DNA, arising from random mutations and internal molecular rearrangements, on which natural selection would act.

Gregor Johann Mendel, an Austrian monk and amateur botanist in the 1860s made a careful study of the inherited characteristics of plants, which discovered the phenomenon of genetic inheritance. Mendel, a shy and modest man, sent his findings to an eminent biologist, who, as one might have expected, dismissed the whole idea as nonsense. Deeply discouraged, Mendel hid his ideas from the world and returned to his plants. His revolutionary work was only rediscovered in 1900, when the science of genetics was really born. Improvements in microscopes made it possible to see inside the cell, leading to the discovering of genes and chromosomes.

Genetics allows us to understand the ever-continuing development of life. The evolution of life meant the appearance of a self-replicating molecule which could transmit the characteristics of the life-form to future generations. Such a mechanism is deoxyribonucleic acid (DNA). This self-reproducing DNA molecule is not concentrated in a particular part of the body, but is contained in every animal or plant cell. The highest evolved species, a product of over 3 billion years of evolution, is the human species. At adulthood, humans are made up of a trillion cells, but at conception there existed only a singled-celled embryo. How does this happen? The secret is in the DNA. Within this single cell was contained the DNA molecule that held the genetic code for the construction of a

human being. The genetic information carried by the genes is stored in a chemically coded form. One gene is a section of DNA that has the information to make a particular type of protein.

The genes contained in every cell are that part of the organism that contains all the necessary information for creating animals and plants. Most genes carry information that direct cells to make proteins. Some genes tell the cells in an embryo where they are and whether they should grow into an arm or a leg. The sequences of bases stored in the genes determine what the living creature will be. The heredity information is stored in the nucleus of each cell in the form of chains of genes called chromosomes. Like a living textbook, two sets of chromosomes carry all the genes allotted to an individual, defining the nature of the structure of the proteins that do most of the work in the body.

Only in the 1950s was the chemical composition of genes identified as DNA. In 1953 Francis Crick and James Watson made a revolutionary breakthrough in genetics with their discovery of the famous double-helix model of the nucleic-acid molecule, for which they shared the Nobel Prize in 1962. This makes clear how chromosomes are duplicated in cell division. DNA is present in the simplest life-forms: a virus possesses a single DNA molecule. All life as we know it depends on DNA in the last analysis. The discovery and development of genetics further unlocked the secrets of evolution. The laws of evolution discovered by Darwin were enriched by the understanding of genetics, through the work of Fisher, Haldane and Wright, the founders of neo-Darwinism.

The gene is the unit of heredity. The entire collection of genes possessed by an organism is called the genome. At present scientists are engaged in a project to identify all the genes of the human genome, which number around 100,000. The genes themselves in each generation of cells reproduce themselves; proteins in the shape of special enzymes play an important role in the process. Through this self-reproduction, genes are formed once again for each new cell. So the genes indirectly produce the proteins that construct and maintain all cells. From bacterial cells, plant cells and animal cells; cells specialized to form leaf and stem, muscle and bone, liver and kidney, and many more, including the brain. Each cell contains the same complement of genes as was present in the original cell. Each human cell probably contains the genetic information needed to make any type of human cell, and therefore an entire human being, but in each cell only a selected portion of that information is used. It is analogous to a book of instructions, where only certain pages, and even only certain lines and words are selected to code the necessary proteins needed in the production of various cells.

The effect of sexual reproduction is to mix or shuffle the genes. The sex cells (egg or sperm) only contain 23 chromosomes each, but when fused make up the normal 46 chromosomes. The new cell would, in the words of Dawkins, be “a mosaic of maternal genes and paternal genes.” As the two sets of chromosomes merge, if two gene signals differ, then one characteristic will prevail over the other. The gene for brown eyes, for instance, is dominant to that for blue. They are what is termed as recessive and dominant genes. Sometimes a hybrid compromise is produced.

It is through reproduction that variation is achieved. From an evolutionary view this is vital. The asexual reproduction of primitive organisms makes identical copies of the parent cell, where mutation is very infrequent. On the other hand, sexual reproduction, with the new combination of genes from two sources, increases the possibilities of genetic variation and accelerates the rate at which evolution can proceed. Each life form carries the DNA code of genetic information. The evidence of our common ancestry is the similarity of cell structure of all living things. The mechanism of inheritance is the same, where DNA determines that mice look like mice, humans look like humans, and bacteria look like bacteria. Some organisms, such as bacteria, possess only one main DNA molecule, whereas our own cells, and those of higher organisms, contain a number of separate bundles of DNA (chromosomes).

Genes and Environment

Over the last 25 years, the twin ideologies of reductionism and biological determinism have been dominant in all branches of biology. The method of reductionism tries to explain the properties of complex wholes — proteins for example — in terms of the properties of the atoms and even the fundamental particles of which they are composed. The further down you went, the better (it was claimed) was the understanding. Further, they assert that the units that compose the whole exist before the whole, that a chain of causation runs from the parts to the whole, that the egg always comes before the chicken.

Biological determinism is very closely related to reductionism. It claims, for example, that the behavior of human beings is determined by the genes possessed by individuals and leads to the conclusion that all human society is governed by the sum of the behavior of all the individuals in that society. This genetic control is equivalent to the older ideas expressed by the term “human nature.” Again scientists may argue that this is not what they mean, but the ideas

of determinism and of genes as “fixed unalterable entities” abound in their statements and are taken up with glee by right wing politicians. For them, social inequalities are unfortunate, but they are innate and unalterable; they are therefore impossible to remedy by social means, as to do so would “go against nature.” This idea has been expressed by Richard Dawkins in *The Selfish Gene* which is used as a textbook in American universities.

The mechanism of evolution is conditioned by the dialectical interrelationship between genes and environment. Prior to Darwin, Lamarck put forward a different theory of evolution, which asserts that the individual adapts itself directly to its environment and passes on these modifications to its offspring. This mechanical interpretation has been completely discredited, although the idea that environment directly alters heredity resurfaced in Stalinist Russia in the guise of Lysenkoism. Human evolution has both a “nature” and a “history.” The genetic raw material enters into a dynamic relationship with the social, economic and cultural environment. It is impossible to understand the process of evolution by taking either one of the two in isolation as there is a constant interaction between the biological and “cultural” elements.

It has been conclusively proved that acquired traits (derived from the environment) are not biologically transmitted. Culture is passed on from one generation to another exclusively by teaching and example. That is one of the decisive features which sets human society apart from the rest of the animal kingdom, although the elements of this can also be observed in the higher apes. It is impossible to deny the vital role of genes in human development, nor is this in the slightest degree in contradiction with materialism. Does it follow, then, that “it’s all in the genes?” Let us quote the words of the celebrated geneticist Theodore Dobzhansky:

Most contemporary evolutionists are of the opinion that adaptation of a living species to its environment is the chief agency impelling and directing biological evolution.

And again:

Culture is, however, an instrument of adaptation which is vastly more efficient than the biological processes which led to its inception and advancement. It is more efficient among other things because it is more rapid — changed genes are transmitted only to the direct descendants of the individuals in whom they first appear; to replace the old genes, the carriers of the new ones must gradually outbreed and supplant the former. Changed culture may be transmitted to anybody regardless of biological parentage, or borrowed ready-made from other peoples.⁸¹

Biologists divide the organism into two parts, the genetic make-up, known as the genotype, and the apparent qualities, the phenotype. It is a common error to regard the relation between the two as a simple relation of cause and effect. The genotype, so the argument goes, comes before the phenotype, and is therefore the decisive element in the equation. We are born with a given set of genes, which cannot be altered, and this decides our fate, as surely as the position of the planets in astrology. This kind of genetic mechanistic determinism is the mirror-image of the quack theories of Lysenko. It is Lamarckism turned inside out. In reality, the genotype, or genes found in the nucleus of every cell, is more or less fixed — give or take the occasional mutation. The phenotype, or the total morphological, physiological and behavior properties of the individual, is not fixed. On the contrary, it changes constantly throughout the life of the organism by interaction between the genotype and the environment and between the phenotype and the environment. In other words, it is a product of dialectic inter-action of organism and environment. If Albert Einstein had been born in a New York slum, or a village in India, it does not take much intelligence to see that his genetic potential would have counted for very little.

The study of genetics provides the conclusive answer to idealism. No organism can exist without a genotype. And no genotype can exist outside a spatiotemporal continuum — an environment. The genes interact with the environment to give rise to the process of human development. As a matter of fact, if hereditary were perfect, there could be no evolution, since heredity is a conservative force. It is essentially a mechanism for self-copying. But there is a built-in contradiction in the genes, whereby occasionally an imperfect copy is produced — a mutation. There is an infinite number of such accidents, most of which are not only useless, but positively harmful to the organism.

A single mutation cannot transform one species into another. The information contained in the gene does not remain there in splendid isolation. It enters into contact with the physical world, where it is tested, processed, articulated and modified. If a particular variant provides a better protein than another in a given environment, it will prosper, while the others are eliminated. At a certain point, small variations reach a qualitative stage, and a new species is formed. This is the meaning of natural selection. For some four billion years, the genes of every living thing — plants and animals, including humans — have been formed in this way. It is not a one-way process. The idea of the genetic determinists, that the genes are preeminent, has been described by Francis

Crick, one of the discoverers of the DNA code, as the “central dogma” of molecular biology. It is no more valid than the dogma of the Immaculate Conception. In the dialectical relationship between the organism and the environment, information about the phenotype flows back into the genotype. The genes are “selected” by the environment, which determines which will survive, and which perish.

The role of the genetic code plays a vital role in establishing the “framework” of human beings, whereas the environment works to fill out and develop behavior and personality. They are not isolated factors, but dialectically fuse together to produce the individual and his or her unique characteristics. No two persons are identical. However, although it is not possible to alter a person’s hereditary make-up, it is entirely possible to alter the environment. The way to improve an individual’s potential is to improve their environment. This idea has provoked a heated argument over many years: is it possible to over-ride or change genetic “deficiencies” through an improved environment? The leading early geneticist Francis Galton tried to demonstrate that genius was hereditary, and favored a policy of selective breeding to maintain the intellectual stock. The idea that middle class and upper class whites were genetically superior to other races and classes permeated Victorian society. It became the ideology of the eugenics movement which advocated forced sterilization to prevent the biologically unfit from propagation. Unsound scientific data using IQ (intelligence quota) testing was used to support biological determinism and social inequalities based on race, sex or class that cannot be altered as they reflect innate inferior genes.

“Intelligence” and Genes

The sociobiologist E. O. Wilson expresses the biological determinist view as follows:

If the planned society — the creation of which is inevitable in the coming century — were to deliberately steer its members past those stresses and conflicts that once gave the destructive phenotypes (aggression and selfishness) their Darwinian edge, the other phenotypes (co-operation and altruism) might dwindle with them. In this, the ultimate genetic sense, social control would rob man of his humanity.⁸²

In other words, by getting rid of the bad aspects of humanity, we may get rid of the good at the same time! Again, Wilson confuses genotype with phenotype by implying that the phenotype (not the genotype) is fixed and unchanging. It is not. Genotypes do not “code” for traits in the phenotype and

there is no gene that is equivalent to altruism in the phenotype. Every living thing is the result of a continuous interaction between the genes, the environment, and the phenotype itself. However, we must also avoid falling into the other trap of believing the organism is putty in the “hands” of genes and the environment. It too is an active part of the process. All living things interact with their environment in a dialectical way.

“To suppose that a sex cell transports a particle called ‘intelligence’ which will make its possessor smart and wise no matter what happens to him is, indeed, ridiculous,” affirms Dobzhansky. “But it is evident that the people we meet are not all alike in intelligence, abilities, and attitudes, and it is not unreasonable to suppose that these differences are caused partly by the natures of these people and partly by their environments.”

Although this clearly demonstrates the materialist and dialectical character of life processes, genetics has given rise to heated controversy and opened the door to idealism and reactionary conceptions. A one-sided fashion of genetics inevitably ends up in error and confusion. Thus, certain geneticists have fallen into the trap of biological determinism or genetic determinism. This is also the case with sociobiologists like E. O. Wilson and Richard Dawkins. Commenting on this, Steven Rose asks:

“Does evolutionary theory imply that certain aspects of human — capitalism, nationalism, patriarchy, xenophobia, aggression and competition — are ‘fixed’ in our ‘selfish genes’? Some biologists have claimed to answer this question in the affirmative, and political theorists of the right — from libertarian monetarists to neo-fascists have seized upon their pronouncements as providing ‘scientific’ justification for their political philosophies.” The only conclusion from this is that capitalism and all its ills are “natural,” being derived from biological facts. Theories of racial and sexual inequality have also sought to base themselves on certain interpretations of science.

Simplistic and crude metaphors of evolution, such as “survival of the fittest” and “the struggle for existence,” made their way through Herbert Spencer into the vocabulary of social Darwinism. Within biology was found the very confirmation of capitalism, class inequalities and imperialism. It appears that the sociobiologists of the E. O. Wilson mould are following in their footsteps with their views of human nature and biological determinism. Marx and Engels explained that “man makes himself.” Human nature, like consciousness, is a product of the prevailing social and economic conditions. That is why human nature has changed throughout history, following the

development of society itself. For the sociobiologist, human characteristics appear biologically fixed through our genes, giving sustenance to the myth that “you can’t change human nature.”

In point of fact, so-called “human nature” has been transformed and re-transformed many times in the course of human history, as Dobzhansky points out:

Darlington (1953) believes that ‘individual adaptability is indeed one of the great illusions of common-sense observation. It is an illusion responsible for some of the chief errors of political and economic administration today. Individuals and populations cannot be shifted from one place or occupation to another after an appropriate period of training to fit the convenience of some master planner, any more than hill farmers can be turned into deep-sea fishermen or habitual criminals can be turned into good citizens.’

Despite all the inadequacy and uncertainty of our knowledge of human genetics, there is plenty of evidence contrary to Darlington’s view, and this evidence is conclusive.

History abounds in proofs that individuals and populations can successfully be shifted from one place or occupation to another. Industrial revolutions in many countries throughout the world have amply shown this. The near ancestors of millions of industrial workers have been mostly ‘timeless’ peasants tilling the soil. The movement from the soil to industrial cities is even now under way, and on a grand scale, in some ‘underdeveloped’ countries.⁸³

IQ Testing

A term frequently misused by genetic determinists is heredity, especially in the field of IQ testing. The psychologists Hans Eysenck in Britain, Richard Herrnstein and Arthur Jensen in the US, have promoted the idea that intelligence is largely inherited. They also maintain that the average IQ of blacks is genetically lower than that of whites, and of Irish in Ireland to English in England. Eysenck apparently believes that blacks and the Irish have been selectively bred for “low IQ” genes. In point of fact, IQ tests have been shown to be inherently flawed. There is no such thing as a unit of measurement for “intelligence,” as there is for height or weight. The IQ is an imaginary concept based upon arbitrary assumptions.

The IQ test originated at the beginning of the century when Alfred Binet established a simple test to help identify children with learning difficulties. For Binet it was a means of identification of difficulties that could then be remedied through “mental orthopedics.” He certainly did not believe that this measure

was of some “fixed” intelligence, and for those who contemplated such ideas Binet’s rebuke was sharp: “We must protest and react against this brutal pessimism.”

The basis of Binet’s test was simple enough: older children should be able to carry out mental tasks that younger children could not. He thus assembled tests suitable for each age group; those considered brighter or less able were judged accordingly. Where children encountered difficulties, then remedial action should be undertaken. However, this system in the hands of others was used to draw different conclusions. With the death of Binet, the advocates of eugenics saw their opportunity to reinforce their determinist message. Intelligence was now considered innate and fixed through heredity and corresponded with social class and racial origin. As Lewis Terman introduced the Stanford-Binet tests into the US, he made it plain that low intelligence “is very common among Spanish-Indian and Mexican families of the South-West and also among Negroes. Their dullness seems to be racial, or at least inherent in the family stocks from which they come...Children of this group should be segregated in special classes...They cannot master abstractions, but they can often be made efficient workers...There is no possibility at present of convincing society that they should not be allowed to reproduce, although from a eugenic point of view they constitute a grave problem because of their unusually prolific breeding.”

This constituted the tone of the US educational establishment in regard to testing. A new twist was also introduced to extend its scientific scope: standards were set for adults, and the ratio between age and mental age — the “intelligence quotient,” or IQ.

In Britain, it was English psychologist Sir Cyril Lodowic Burt who translated and championed even more obsessively than his American counterparts Binet’s tests. He claimed that men were more intelligent than women on the basis of alleged studies. The same gentleman alleged that he possessed the strongest scientific evidence that Christians were more intelligent than Jews, Englishmen than Irishmen, upper-class Englishmen than lower-class Englishmen, and so on. Not surprisingly, Burt himself just happened to be an upper-class, Christian English male! By such means the oppressors justify oppression, the wealthy and powerful justify their privileges, on the grounds that their victims are “inferior.” For some 65 years, until his death in 1971, Burt continued his work on eugenics and IQ testing, being duly knighted for his services to mankind. He helped to establish the notorious “eleven plus”

education system, which segregated children between “secondary modern” and grammar schools. Burt explained: “Capacity must obviously limit content. It is impossible for a pint jug to hold more than a pint of milk; and it is equally impossible for a child’s educational attainments to rise higher than his educable capacity permits.”

So Binet’s tests were twisted beyond recognition to reinforce the class character of society. There were those born to be hewers of coal and carriers of water, and those who would rule over society. The tests were not used to remedy, but to segregate. Whatever the modification of the IQ test, they all have the same roots: a preconceived “intelligence” that is the hallmark on which all are judged. However these tests are overwhelmingly influenced by culture and social stereotypes that determine the results. Again they are linked to school performance, and reflect those results. However, the idea that it is possible to identify or measure “intelligence” in this crude fashion is fundamentally false. After all, what is intelligence? How can it be quantified? It is not like weight or height. Intelligence is not fixed, as Burt claimed, but elastic. The potential of a human brain is limitless. To allow a human being to fulfill this potential is the task of society. Environmental facts can greatly restrict potential or enhance it. Bring up children in bad social conditions, and they will be disadvantaged in comparison with those brought up with all their needs provided. Social background is extremely important. If you change the environment, you change the child. Despite the claims of the biological determinists, intelligence is not fixed or genetically predetermined.

The obsession to statistically plot “intelligence” through the bell-shaped curve is an attempt to enforce social conformity. Those outside of the norm are said to be “abnormal” and in need of treatment. Alternately, it is genetic, and determines our class, race, and life. But in reality, whereas our genotype is fixed, our phenotype changes constantly. The loss of an arm or leg is irreversible but not heritable. Wilson’s disease is heritable but with drugs not irreversible. “Nor, of course,” says Rose, Kamin, and Lewontin, “does the phenotype develop linearly from the genotype from birth to adulthood. The ‘intelligence’ of an infant is not merely a certain small percentage of that of the adult it will become, as if the ‘pint jug’ were being steadily filled.”

Burt’s frantic attempts to shore up the genetic basis of IQ, led him systematically to falsify his records and data. His celebrated IQ study of separated identical twins resulted in his incredible assertion that there was no correlation between the environments of the separated pairs. For him, everything was

determined by the twin's genes. He was the idol of the genetic determinists, and his work gave them the ammunition to further their cause. In 1978, D. D. Dorfman, an American psychologist, proved conclusively that this respectable scientist and English gentleman had simply invented his results. After his exposure as a fraud, his supporters were forced to change tack, simply berating Burt for his scientific carelessness! Burt's work was the IQ equivalent to the Piltdown Man. And yet at the time — despite fifteen years of glaring inconsistencies — his researches were hailed by the scientific establishment as proof of the inheritability of IQ. Despite Burt's demise, the establishment still clung to his reactionary philosophy as the cornerstone of their class outlook.

The more recent studies, involving separated identical twins in Britain, America and Denmark, do not in any meaningful way prove the inheritability of IQ. These studies have been convincingly answered by Rose, Kamin and Lewontin. Their conclusion? "We do not know what the heritability of IQ really is. The data simply do not allow us to calculate a reasonable estimate of genetic variation for IQ in any population. For all we know, the heritability may be zero or 50%. In fact, despite the massive devotion of research effort to studying it, the question of heritability of IQ is irrelevant to the matters at issue. The great importance attached by determinists to the demonstration of heritability is a consequence of their erroneous belief that heritability means unchangeability."

"Neither for IQ nor for any other trait can genes be said to determine the organism," they continue. "There is no one-to-one correspondence between the genes inherited from one's parent and one's height, weight, metabolic rate, sickness, health, or any other nontrivial organic characteristic...every organism is the unique product of the interaction between genes and environment at every stage of life."⁸⁴

Eugenics

Eugenics was a word coined in 1883 by Francis Galton, who was a cousin of Darwin's. The desire to "improve" the human stock is frequently related to pseudo-scientific theories put forward by those who wish to demonstrate the "superiority" of a particular group — race, nation, social class, or sex, in terms of blood or "good breeding." Such reactionary nonsense is usually given a spurious "scientific" air to convey an impression of intellectual respectability to the most irrational and abhorrent prejudices. America, the "land of the free," saw the triumph of the eugenics movement in the enactment of laws for the compulsory

sterilization of the “biologically inferior.” The state of Indiana passed the first sterilization act in 1907. This practice could be carried out on those considered insane, imbecilic or moronic, as recommended by a board of experts. Seventy years ago, John Scopes taught evolution using a book entitled *A Civic Biology*, by G. W. Hunter, which contained the infamous case of Jukes and Kallikaks. Under the heading *Parasitism and Its Cost to Society — the Remedy*, it says:

“Hundreds of families such as those described above exist today, spreading disease, immorality and crime to all parts of this country. The cost to society of such families is very severe. Just as certain animals or plants become parasitic on other plants or animals, these families have become parasitic on society. They not only do harm to others by corrupting, stealing or spreading disease, but they are actually protected and cared for by the state out of public money. Largely for them the poorhouse and the asylum exist. They are true parasites.

“If such people were lower animals, we would probably kill them off to prevent them spreading. Humanity will not allow this, but we do have the remedy of separating the sexes in asylums or other places and in various ways preventing intermarriage and the possibilities of perpetrating such a low and degenerate race.”

By the 1930s, over 30 states in America had passed sterilization laws, expanding those eligible for treatment to alcoholics and drug addicts, and even blindness and deafness in others. The campaign reached its height in 1927, when the Supreme Court, by 8-1 votes, upheld the Virginia sterilization law in *Buck v. Bell*. This case involved an eighteen year old white girl called Carrie Buck, who was involuntarily incarcerated in the State Colony for Epileptics and Feeble-Minded, and was the first person to be sterilized under the act. She was chosen, according to Harry Laughlin, the superintendent of the Eugenics Record Office (who wanted to eliminate “the most worthless one-tenth of our present population”), as she, her daughter and her mother were genetically mentally subnormal. This information was largely accrued from the Stanford-Binet test of IQ — which was later proved to be totally wrong. The judge in the case, O. W. Holmes, stated “Three generations of imbeciles are enough.” Carrie’s sister Doris was also covertly sterilized under the same law. Carrie’s child, Vivian, died in 1932 of an illness. Her teachers described her as “very bright.”

By January 1935, around 20,000 forced sterilizations for eugenic purposes were carried out in the US. Laughlin wanted the net to include “homeless, tramps and paupers” and was taken up most fervently in Nazi Germany, where the *Erbgesundheitsrecht* led to the sterilization of some 375,000, including 4,000

for blindness and deafness. In the USA, in the end, 30,000 were sterilized against their will. While classical eugenics has been discredited, new versions such as psychosurgery have emerged. This proclaims the idea that surgery on the brain can alleviate social problems, notably violence. Two American psychosurgeons, Vernon Mark and Frank Ervin, went so far as to argue that city riots in the US are caused by mental problems (deranged amygdalas) and may be cured by brain surgery on certain ghetto leaders. Research into this area of biology is being financed by the US law enforcement agencies.

Seeking suitable candidates for brain surgery, a revealing letter from 1971 between the Director of Corrections, Human Relations Agency, Sacramento, and the Director of Hospitals and Clinics, University of California Medical Center, shows the mentality of sections of the “scientific” community. The Director asks for suitable prison candidates “who have shown aggressive, destructive behavior, possibly as a result of severe neurological disease” to conduct “surgical and diagnostic procedures...to locate centers in the brain which may have been previously damaged and which could serve as the focus for episodes of violent behavior,” for surgical removal.

The reply suggests a candidate who “was transferred...for increasing militancy, leadership ability and outspoken hatred for white society...he was identified as one of several leaders in the work strike of April 1971...Also evident at approximately the same time was an avalanche of revolutionary reading material.” These crank ideologies are the theoretical backdrop of political reaction. In 1980, Dr. K. Nelson, the then director of the Lynchburg Hospital where Carrie Buck was sterilized, discovered that over 4,000 operations had been carried out, the last as late as 1972. The IQ tests used in the Buck case have long been discredited. These reactionary ideas of forced sterilization are not simply confined to the “dark ages” of the past, but are alive today, sustained on pseudo-scientific theories, particularly in America. Even now, there are sterilization laws on the statute books of 22 US states.

Crime and Genetics

Since the early 1970s the proportion of Americans in prison has more than tripled. In Britain those behind bars is at record levels. Prisons are so overcrowded that inmates are kept in police cells. “The UK in 1991 had a higher proportion of its population in jail than every Council of Europe nation apart from Hungary,” comments the Financial Times (10th March 1994). Despite this

violent crime remains high in both countries. This crisis has witnessed a flowering of reactionary ideas attempting to link criminal behavior to biological factors. "For every 1% that we reduce violence, we save the country \$1.2 billion," says American psychologist Adrian Raine. As a result, the US National Institute of Health has increased its budget for violence-related research to \$58 million. And in December 1994 the National Science Foundation began promoting proposals for a \$12 million, five-year research consortium. "With the expected advances, we're going to be able to diagnose many people who are biologically brain-prone to violence," claims Stuart Yudofsky, chair of the psychiatry department at Baylor College of Medicine in the *Scientific American* of March 1995.

It has become fashionable in certain circles to attribute all kinds of things to genetic or biological disorders, rather than recognizing that social problems arise from social conditions. The school of genetic determinism has drawn all types of reactionary conclusions, reducing all social problems to the level of genetics. Not long ago, research apparently revealed that many violent criminals had an extra Y chromosome, but more recent studies show the connection to be irrelevant. Now evidence of less activity in the frontal cortex of the brain of murderers is attracting attention as the link between biology and violence. There is a proposal for a Federal Violence Initiative to identify at least 100,000 inner-city children "whose alleged biochemical and genetic defects will make them prone to violence in later life."

The dangers of phony research leading to genetic links to race and criminal or antisocial behavior is ever present. False conclusions can be drawn from the statistic that in the US, where 12.4% of the population are blacks, they account for 44.8% of arrests for violent crime. In the same article in *Scientific American* we read: "There is reason to be concerned that ostensibly objective biological studies, blindly ignoring social and cultural differences, could misguidedly reinforce racial stereotypes." Due to this threat, boycotts have taken place over blood and urine samples being taken from racial minorities. So, according to Raine, "all the biological and genetic studies conducted to date have been done on whites."

Raine continues: "Imagine you are the father of an eight-year old boy. The ethical dilemma is this: I could say to you, 'Well, we have taken a wide variety of measurements, and we can predict with 80% accuracy that your son is going to become seriously violent within 20 years. We can offer you a series of biological,

social and cognitive intervention programs that will greatly reduce the chance of his becoming a violent offender.'

"What do you do? Do you place your boy in those programs and risk stigmatizing him as a violent criminal even though there is a real possibility that he is innocent? Or do you say no to the treatment and run an 80% chance that your child will; grow up (a) destroy his life, (b) destroy your life, (c) destroy the lives of his brothers and sisters and, most important, (d) destroy the lives of the innocent victims who suffer at his hands?"

Firstly, it is not possible to predict a child's future criminal behavior at all — let alone with 80% accuracy. And secondly, this puts the blame for crime on the individual. This reactionary argument fails to see crime, violence, and other social ills, as a product of the society we live under. It is a society based upon human exploitation and the maximization of profit that results in mass unemployment, homelessness, poverty, and the denigration of life. These social conditions, in turn, produce crime, violence, and brutality. This is nothing to do with genes or biology, and everything to do with the barbarism of capitalist society.

The biological determinists are used to bolster up reactionary social ideas. It is not society that is to blame for crime, poverty, unemployment, etc., but the individual, through their genes or defective biology. The answer, therefore, is brain or genetic surgery. Others look for abnormal levels of testosterone, or slower heartbeats as the explanation of human violence. Some scientists have pointed to the low levels of serotonin, a chemical that in the body affects, amongst other things, the functioning of the brain. Thus, C. R. Jeffery wrote in the *Journal of Criminal Justice Education*: "By increasing the level of serotonin in the brain, we can reduce the level of violence." So serotonin boosters, like the antidepressant Prozac, are administered to patients to cure their aggression. The falsehood of this view is explained by the fact that this chemical can rise or drop in different parts of the brain at different times, with different effects. Environment can also affect levels. However, these "facts" are not allowed to get in the way, or prevent these people from making outrageous claims to bolster their reactionary views.

Jeffery advocates that "Science must tell us what individuals will or will not become criminals, what individuals will or will not become victims, and what law enforcement strategies will or will not work." Yudofsky reinforces Jeffery's enthusiasm with his assertion: "We are now on the verge of a revolution in genetic medicine. The future will be to understand the genetics of aggressive

disorders and to identify those who have greater tendencies to become violent.” He believes that hyperactive children should be tested, and, if necessary, given beta blockers, anticonvulsants or lithium. Yudofsky says these drugs will be “cost effective” and a tremendous “opportunity for the pharmaceutical industry.” It is not difficult to see on which side his bread is buttered.

“There are areas where we can begin to incorporate biological approaches,” argues Fishbein. “Delinquents need to be individually assessed.” She goes on to advocate compulsory treatment for criminals, but if this is unsuccessful, “they should be held indefinitely.” Masters believes that “we now know enough about the serotonergic system so that if we see a kid doing poorly in school, we ought to look at his serotonin levels.”

Racism and Genetics

The United States senate was told in 1899 that “God has not been preparing the English-speaking and Teutonic peoples for a thousand years for nothing but vain and idle self-admiration...He has made us adept in government that we may administer government among savages and senile people.”

B. Shockley, the co-inventor of the transistor, argued that, since blacks are genetically less intelligent than whites, they should not be given equal opportunities, a view also held by the well-known psychologist Hans J. Eysenck. Human nature is seen as the source and explanation of all social ills, having drawn certain distorted parallels with the life-styles of other animals. The broader claims of sociobiology is that racism and nationalism are natural extensions of tribalism, which, in turn, is a product of “kin selection.” “Nationalism and racism,” states E. O. Wilson, “are culturally nurtured outgrowths of simple tribalism.” This idea has even been suggested by Richard Dawkins: “Conceivably, racial prejudice could be interpreted as an irrational generalization of a kin-selected tendency to identify with individuals physically resembling oneself and to be nasty to individuals different in appearance.”⁸⁵

According to the father of sociobiology, E. O. Wilson, “in hunter-gatherer societies, men hunt and women stay at home. This strong bias persists in most agricultural and industrial societies and on that ground alone appears to have a genetic origin.” He says that men are “naturally” polygamous, while women are “naturally” monogamous. The characteristic of sociobiology is the comparison of human social relations with the animal world, as justification for male dominance and class structure. “The genetic bias,” says Wilson, “is intense

enough to cause a substantial division of labor even in the most free and most egalitarian of future societies.” This is the theme, based on the animal world, which zoologist Desmond Morris attempts to popularize.

The recent attempts to prove that intelligence is inherited has centered around IQ testing. *The Bell Curve* by Charles Murray, which regurgitates the old argument that genetics explains the gap between the average IQ of American whites and blacks. The fundamental arguments in this book have been repeatedly demolished. According to psychiatrist Peter Breggin, it is an attempt to “resurrect the King Kong image of Afro-Americans as violent and stupid.” (*The Guardian*, March 13, 1995). But the most crushing evidence against the theories of genetic determinism come from a recent book entitled *The History and Geography of Human Genes* by population geneticists Luca Cavalli-Sforza, Paolo Menozzi and Alberto Piazza. The book is a remarkable synthesis of more than 50 years research in population genetics. It is the most authoritative account to date of how humans vary at the level of their chromosomes. The firm conclusion of the book is that, once the genes for surface traits such as coloration and stature are discounted, the human ‘races’ are remarkably alike under the skin. That variation between individuals is far greater than the variation among groups. According to the magazine *Time*, “In fact, the diversity among individuals is so enormous that the whole concept of race becomes meaningless at the genetic level. The authors say there is ‘no scientific basis’ for theories touting the genetic superiority of any one population over another.” (January 16, 1995.)

In reviewing the book, the *Time* article states: “Despite the difficulties, the scientists made some myth-shattering discoveries. One of them jumps right off the book’s cover: a color map of the world genetic variation has Africa on one end of the spectrum and Australia on the other. Because Australia’s aborigines and sub-Saharan Africans share such superficial traits as skin color and body shape, they were widely assumed to be closely related. But their genes tell a different story. Of all humans, Australians are most distant from the Africans and most closely resemble their neighbors, the Southeast Asians.” The review concludes, “What the eye sees as racial differences — between Europeans and Africans, for example — are mainly adaptations to climate as humans moved from one continent to another.” The book also confirms that the birthplace of humanity and so the starting point for the original human migrations was Africa, thereby demonstrating that the split from the African branch is the oldest on the human family tree.

The use of biological and genetic theories to justify reactionary policies is not a new phenomenon, although in the last decade or so it has been given a new lease of life by the general tendency of Western governments to go onto the offensive against the welfare state and all the other social conquests of the working class. The law of the market — that is the law of the jungle — is back in fashion. That includes, of course, the universities, where there are always enough people willing to swim with the prevailing current, which does their career prospects no harm whatsoever.

There are many honest academics who approach their subject in a dispassionate manner, but it would indeed be naïve to believe that the fact that a person has a string of letters after his or her name makes them immune from the pressures of the society in which they live, whether they are aware of it or not. In 1949, N. Pastore conducted a study into the opinions of twenty four psychologists, biologists and sociologists concerning the so-called nature-nurture problem. Out of twelve “liberals or radicals,” eleven said the environment was more important than heredity, and one the opposite. In the conservative camp, the result was exactly the opposite — eleven hereditarians and only one environmentalist! Dobzhansky found this result “disconcerting.” For our part, we find it quite predictable.

Roger Scruton draws the social lessons: “Bioeconomics says that government programs that force individuals to be less competitive and selfish than they are genetically programmed to be are preordained to fail.” This fitted in perfectly with the reemergence of genetic determinism in America, and their proof that blacks were inferior to whites, and the working class was inferior to the middle and upper classes. The scientific backing for such fallacies is used to create an aura of so-called respectability and “objectivity.”

The Selfish Gene

Richard Dawkins, who came to fame with his controversially entitled book *The Selfish Gene*, has been at the center of a heated polemic over genetics. Molecular biologists have identified the importance of DNA in replicating copies of DNA molecules. They possess coded instructions which produce the building blocks of life, amino acids. These make up proteins which shape cells and organs. Because of this, some molecular biologists and also sociobiologists have argued that all natural selection acts ultimately at the level of the DNA. This has led a number of scientists to have become so obsessed with the wondrous nature of

the gene, that not a few are unable see the wood for the trees. Some have given the gene mystical qualities from which reactionary ideas are drawn. The idea that a person's physical, mental and moral characteristics are handed down unaltered and unalterable from genes is certainly not supported by the facts of genetic science. Yet it has cropped up again and again in literature and has had a serious effect on social policy throughout the 20th century.

The gene transmits its influence from parent to offspring. It can only be defined as a difference between a number of different genes (called alleles) influencing the same thing (e.g. blue/brown alleles for eye color). The difference is identified by means of biochemical, physiological, structural or behavioral testing/observation (after other sources of variation, like environment, have been excluded).

Unfortunately, many scientists and others use a misleading shorthand for the above definition. Particularly, that a gene that contributes to an individual animal behaving differently becomes the gene for its distinctive behavior. Dawkins is not the only scientist that falls into this trap. In the 1970s many spoke of a gene coding for physical and behavioral characteristics. Also a gene must be compared with another for the same trait. It is not an entity that stands alone in its own right. As J. B. S. Haldane correctly pointed out, genetics is the science of differences not similarities. Quite simply, you and I can both be selfish — the differences between us cannot. You cannot apply personal characteristics to a comparison. In his book, *The Selfish Gene*, Dawkins jumps back and forth from one definition to the other, claiming that they are interchangeable — which they are not. The result has been to encourage biological determinism. A whole generation of American and other scientists are being brought up on this confusion.

The scientific research into genetics shows the possibilities for medicine, where gene disorders such as Huntington's chorea, Duchenne muscular dystrophy, and others have been identified. However, there are widespread assertions that in some way genes are responsible for all kinds of things, like homosexuality and criminality. This genetic determinism reduces all social problems to the level of genetics. In February 1995, a conference on Genetics of Criminal and Anti-Social Behavior was held in London. Ten of the thirteen speakers were from the United States where a similar conference in 1992 with racist overtones was abandoned because of public pressure. While the chairperson, Sir Michael Rutter of the London Institute of Psychiatry stated "there can be no such thing as a gene for crime," other participants, like Dr.

Gregory Carey of the Institute of Behavioral Genetics, University of Colorado, maintained that genetic factors as a whole were responsible for 40-50% of criminal violence. Although he said it would be impractical to “treat” criminality through genetic engineering, others said there were good prospects for developing drugs to control excessive aggression, once the responsible genes had been found. He suggested, however, that abortion should be considered when antenatal testing indicates a child is likely to be born with genes predisposing it to aggression or antisocial behavior. His view was endorsed by Dr. David Goldman from the Laboratory of Neurogenetics at the US National Institutes of Health. “The families should be given the information and should be allowed to decide privately how to use it.” (*The Independent*, February 14, 1995.)

According to Professor Hans Brunner of Nijmegen University Hospital in Holland, men in a family who inherited a particular genetic abnormality of the X chromosome which led to a deficiency in an enzyme concerned with messages in the brain, have shown “impulsive aggression” including arson and attempted rape. Dr. David Goldman of the NIH Laboratory of Neurogenetics in Maryland, and Professor Matti Virkkunen of the University of Helsinki said they were discovering aggression-related genetic variations in the way people process brain chemicals. “Pharmaceutical companies are already interested in our findings,” said Virkkunen (*The Financial Times*, February 14, 1995).

Steven Rose described the conference as “troublesome, disturbing and unbalanced.” The event was attacked in a letter by 15 scientists. Dr. Zakari Erzinclioglu, director of the Center for Forensic Science at Durham University, called it “very disturbing, simple minded and mischievous.” Ashley Montague pointed out that “it is not ‘criminal genes’ that make criminals, but in most cases ‘criminal social conditions.’”

Richard Dawkins’ *The Selfish Gene*, originally published in 1976, makes some startling assertions. “We are born selfish,” says Dawkins. Although he says that “genes have no foresight” and “they do not plan ahead” Dawkins imbues genes with a consciousness and a “selfish” identity. They strive to replicate themselves, as if they are consciously planning how best this could be achieved:

“Certainly in principle, and also in fact, the gene reaches out through the individual body wall and manipulates objects in the world outside, some of them inanimate, some of them other living beings, some of them a long way away. With only a little imagination we can see the gene as sitting at the center of a radiating web of extended phenotypic power. And an object in the world is the center of a converging web of influences from many genes sitting in many

organisms. The long reach of the gene knows no obvious boundaries.”⁸⁶ Because for Dawkins individual organisms do not survive from one generation to another, while genes do, it follows that natural selection acts on what survives, namely, the genes. Therefore, all selection acts ultimately at the level of DNA. At the same time, each gene is in competition with each other to reproduce themselves in the next generation. “What after all, is so special about genes? The answer is that they are replicators.”

In this view, the replicator of life is the gene; thus the organism is simply the vehicle for the genes (“survival machines — robot vehicles blindly programmed to preserve the selfish molecules known as genes” ... “they swarm in huge colonies, safe inside gigantic lumbering robots”). It is a recasting of Butler’s famous aphorism that a hen is simply the egg’s way of making another egg. An animal, for Dawkins, is only DNA’s way of making more DNA. He imbues the genes with certain mystical qualities which is essentially teleological.

“I suspect,” says Dawkins in his defense, “that both Rose and Gould are determinists in that they believe in a physical, materialistic basis for all our actions. So am I...whatever view one takes on the question of determinism, the insertion of the word ‘genetic’ is not going to make any difference.” He then adds, “if you are a full-blooded determinist you will believe that all your actions are determined by physical causes in the past...what difference can it possibly make whether some of those physical causes are genetic? Why are genetic determinists thought to be any more ineluctable, or blame-absolving, than ‘environmental ones’?”⁸⁷

Everything in nature has a cause and an effect, in which an effect in its turn becomes a cause. Dawkins mixes up determinism and fatalism: “An organism is a tool of DNA.” Genetic determinism has a precise meaning, where genes are said to “determine” the exact nature of the phenotype. There is no doubt that genes have a powerful effect in the form of the organism, but its entity will be decisively influenced by the environment. For example, if two identical twins are placed into two totally different environments, two different characters will be produced. As Rose explains, “In reality, however, selection must act at a multitude of levels. Individual gene-sized lengths of DNA may or may not be selected in their own right, but that DNA is expressed against the background of the entire genotype; particular assemblies of genes or whole genotypes must therefore themselves represent another level of selection. Further, the genotype exists within a phenotype, and whether that phenotype survives or does not

depends on its interaction with others. Hence it will only be selected against the background of the population in which it is embedded.”⁸⁸

Dawkins was forced to back-track to some extent, modifying his arguments in the later editions of *The Selfish Gene* (1989) and in *The Extended Phenotype* (1982). He says his flamboyant language left him open to misrepresentation and misunderstanding: “It is all too easy to get carried away, and allow hypothetical genes cognitive wisdom and foresight in planning their ‘strategy.’” He nevertheless defends his fundamental argument and views life “in terms of genetic replicators preserving themselves by means of their extended phenotypes.” And that “natural selection is differential survival of genes.” Dawkins now says “genes may modify the effects of other genes, and may modify the effects of the environment. Environmental events, both internal and external, may modify the effects of genes, and may modify the effects of other environmental events.” But this concession aside, Dawkins’ main thesis remains.

For instance, he says: “Contraception is sometimes attacked as ‘unnatural.’ So it is, very unnatural. The trouble is, so is the welfare state. I think that most of us believe the welfare state is highly desirable. But you cannot have an unnatural welfare state, unless you also have unnatural birth control, otherwise the end result will be misery even greater than that which obtains in nature.” He continues, “the welfare state is perhaps the greatest altruistic system the animal kingdom has ever known. But any altruistic system is inherently unstable, because it is open to abuse by selfish individuals, ready to exploit it. Individual humans who have more children than they are capable of rearing are probably too ignorant in most cases to be accused of conscious malevolent exploitation.”

According to Dawkins child adoption is against the instincts and interests of our “selfish genes.” “In most cases we should probably regard adoption, however touching it may seem, as a misfiring of an in-built rule,” says Dawkins. “This is because the generous female is doing her own genes no good by caring for the orphan. She is wasting time and energy which she could be investing in the lives of her own kin, particularly future children of her own. It is presumably a mistake which happens too seldom for natural selection to have ‘bothered’ to change the rule by making the maternal instinct more selective.”

He says that “if a female is presented with reliable evidence that a famine is expected, it is in her own selfish interests to reduce her own birth-rate.” Dawkins also believes that natural selection would favor children who cheat, lie, deceive and exploit and that “when we look at wild populations we may expect to see cheating and selfishness within families. The phrase ‘the child should

cheat' means that genes which tend to make children cheat have an advantage in the gene pool." ⁸⁹ He concludes that the organism is a tool of DNA, rather than the other way around.

These comments are interesting not so much for what they tell us about genes, but for what they reveal about the state of society in the last decade of the 20th century. In certain societies, powerful muscles or the ability to run fast can confer a genetic advantage. If a similar advantage is attributed to the propensity to lie, cheat and exploit, it must mean that such features are the qualities most necessary to succeed in modern society, and this is perfectly correct from the standpoint of the advocates of "market values." While it is extremely questionable that such qualities can, in fact, be passed on through the genetic mechanism, it is certainly the fact that they form the most essential features of the egoism of the bourgeois. The "war of each against all," as old Hobbes puts it, is the basic standpoint of capitalist society.

Is it true that such a mentality is a genetically conditioned part of "human nature"? Let us remind ourselves that capitalism and its values has only existed at most for the last 200 years out of approximately 5,000 years of recorded history, and 100,000 years of human development. Human society, for the overwhelming majority of its existence, has been based on the principle of co-operation. Indeed, human beings could never have raised themselves above the level of animals without this. Far from being an essential component of the human psyche, competition is a recent phenomenon, a reflection of a society based on the production of commodities, which twists and perverts human nature into patterns of behavior which would have been considered abhorrent and unnatural in the past.

It is too easy to blame some mysterious phenomenon such as "our genes" for the grasping self-centered morality of the market place. Moreover, this is not a question of zoology, but of social class. Individual capitalists compete against each other and do not hesitate to use any methods to ruin their rivals — lying, cheating, industrial espionage, insider dealing, predatory take-overs — these are considered to be normal commercial practice. From the standpoint of the working class, things are very different. It is not a question of individual morality, but precisely of social survival (the sociological equivalent of "the survival of the fittest"). The only power the working class possesses against the employers is the power of unity, that is precisely of co-operation.

Without organization, beginning at the trade union level, the working class is only raw material for exploitation. The workers' need to combine in the

defense of their interests is a lesson that has to be learned over and over again. Selfishness and “individualism” (in the bourgeois sense of the word) is quite self-defeating for the working class. Every strike-breaker is presented as a great defender of “individual freedom” by the millionaire press because it is in the interest of the employers to atomize the working class, to reduce it to its component parts, utterly at the mercy of Capital. Here too, the dialectical law holds good that the whole is greater than the sum of the parts. Consciously or not, those who present selfishness as an ideal, or at least as “human nature,” have taken up a definite position in relation to the struggle between wage labor and Capital, and cannot complain if they are criticized for providing grist to the Thatcherite mill.

Dawkins sees evolution not as the outcome of a struggle of organisms, but as a struggle between genes seeking to copy themselves. The bodies they inhabit are secondary. He discards the Darwinian principle that individuals are the units of selection. This is a fundamentally false idea. Natural selection deals with organisms, with bodies. It favors some bodies because they are better suited to their environment. The gene is a piece of DNA enclosed within the cell nucleus, large numbers of which contribute to the development of most body parts. This in turn is affected by a whole series of environmental factors, internal and external. Selection does not work directly on parts. Natural selection works on bodies because they are in some way “fitter,” i.e., stronger, fiercer, warmer, and so on. If there is a particular gene for strength or other such specific attributes, then Dawkins may be correct. But that is not the case. There is not one gene for one bit of anatomy. For instance, the instructions for the construction of the ear is contained in a host of separate genes, half of which have come from either parent.

As Stephen Jay Gould explained: “It (natural selection) accepts or rejects entire organisms because suites of parts, interacting in complex ways, confer advantages...Organisms are much more than amalgamations of genes. They have a history that matters; their parts interact in complex ways. Organisms are built by genes acting in concert, influenced by environments, translated into parts that selection sees and parts invisible to selection. Molecules that determine the properties of water are poor analogues for genes and bodies.”⁹⁰

This analysis is backed up by Steven Rose in his criticism of Dawkins: “In reality however selection must act at a multitude of levels. Individual gene-sized lengths of DNA may or may not be selected in their own right, but that DNA is expressed against the background of the entire genotype; particular assemblies

of genes or whole genotypes must therefore themselves represent another level of selection. Further, the genotype exists within a phenotype, and whether that phenotype survives or not depends on its interaction with others. Hence it will only be selected for against the background of the population in which it is embedded.”⁹¹

Dawkins’ method leads him into the swamp of idealism, when he attempts to argue that human culture can be reduced to units he calls memes, which, apparently, like genes, are self-replicating and compete for survival. This is clearly wrong. Human culture is passed down from generation to generation, not through memes, but through education in the broadest sense. It is not biologically inherited but has to be painstakingly relearned and developed by each new generation. Cultural diversity is bound up not with genes but social history. Dawkins’ approach is essentially reductionist.

Societies are broken down to organisms, organisms to cells, cells to molecules, and molecules to atoms. For Dawkins, human nature and motivation are to be understood by analyzing human DNA. The same is true of James Watson (the discoverer, with Crick and Franklin, of the double helix) who said “What else is there but atoms?” They never allow the existence of either multiple levels of analysis or complex modes of determination. They ignore the essential relations between cells and the organism as a whole. This empirical method, which emerged with the scientific revolution at the birth of capitalism, was progressive in its day, but has now become a fetter on the advancement of science and the understanding of nature.

The Future of Genetics

“Until very recently, the only access to the genes which shape the natural world was through environmental change. Now those genes can be manipulated directly. That makes a change easy, immediate and comprehensible; the technology that enables direct genetic manipulation also opens genes’ activity up to inspection. But at the same time it makes change arbitrary, because genes that no animal would spontaneously evolve become possible. These new techniques give humanity unprecedented powers to change the world — and to change itself.” (*The Economist*, February 25, 1995.)

Over the past three decades, colossal advances have been made in the field of molecular genetics. In 1972, the first gene was isolated and reproduced (“cloned”) in a laboratory. The consequences of this were so worrying, that

scientists considered a voluntary moratorium on the recombination of the cloned genes into the DNA of other organisms. But now the introduction of cloned genes into humans has become almost routine. By the first decade of the next century scientists will know the true names of all the proteins in the human body. Such knowledge has tremendous implications for the future — for good or ill.

Until this moment, the gene was shrouded in mystery, like Kant's Thing-in-Itself. The gene was the stern master of human destiny, implacable, unalterable, unfathomable. To talk about our genes was not only to talk about our inheritance. It was to talk about our fate. And fate is a court against which there is no appeal. Until this moment. But now, for the first time in the history of life on our planet, the possibility exists of human beings controlling their own destiny, at the deepest levels. Contrary to the nonsense of the genetic reactionaries, it was never true that genes completely determined human evolution. Although they play a major role in human life, genes do not control it. At most, they establish certain parameters which limit or permit. But now the genotype itself, for the first time, is being brought under control. This is a revolutionary development, pregnant with great consequences for the future of humanity.

The emergence of life out of inorganic matter was a giant evolutionary leap. After a whole series of transformations, the development of a thinking brain as the product of social life and collective labor, was another giant step. Matter becomes conscious of itself. Now, for the first time in four billion years, human beings are in the process of mastering the secrets of their own evolution. Natural selection ceases to be a blind, mysterious force. The all-powerful genotype can be brought under the control of the phenotype. Humankind has the potential to determine its own destiny, and modify the harsh dictates of natural selection.

"Just as organisms are interpretations of genetic information within a specific environment," writes Oliver Morton, "so the use of this genetic knowledge will depend on the environments — economic and ethical, personal and political — in which that use is made. But those uses, good or ill, will surely be made. The genes that imperiously limited and permitted will be bent to human will; limits will become movable, permissions stretched. Genes have never been the complete masters of human destiny, but nor have they been humanity's servants. Until now." (*The Economist*, February 25, 1995)

It is as futile to bemoan these discoveries as it was for desperate groups of workers to break machines in the early days of the Industrial Revolution. The

discoveries of science and technology are a vital part of the development of society, allowing humankind to gain greater control over the constraints imposed by nature. Only in this way can humanity become truly free. The problem is not what the human mind discovers. The problem is how the discoveries are used. The advances of science open a new and breathtaking horizon of unlimited human development. But there is another, darker side to all this. The 20th century carries a terrible message of what horrors can come from capitalism in its epoch of historical decline. The techniques of genetic engineering in the hands of uncontrolled monopolies, interested only in making big profits, poses a ghastly threat.

The entire development of technology, which is constantly breaking down all barriers, and uniting the world in a way that has never been seen before, is an argument in favor of a world planned economy. Not the monstrous caricature of Stalinism, but a democratically-run society, in which men and women would achieve conscious control over their lives and destinies. On the basis of a harmonious planned economy, pooling the resources of the entire planet, a vista of unlimited development opens up. On the one hand, we have the task of nurturing our own world, of making it fit for human beings, of repairing the ravages caused by the greed of irresponsible multinationals. On the other, we have before us the greatest challenges yet contemplated by our species — the exploration of space, linked to the question of the future survival of humankind. The science of genetic engineering, now in its infancy, may in the future be linked to the demands of long space voyages. At present, this is in the realm of speculation. Yet the history of the last hundred years has shown just how rapidly ideas which seemed to be fantastic have been overtaken by reality.

What we see at this moment in time is a colossal potential. In the context of a democratic, harmoniously planned economy, where men and women freely and consciously determine their destinies, the science of genetics will cease to be a block on human progress and will take its proper place in the study and transformation of life itself. This is not fantasy, but corresponds to actual possibilities. In the words of Oliver Morton:

The possibilities of this biology are almost endless. The natural world, including the human body and mind, will become malleable. Implanted organs may refashion the brain, designer viruses rebuild old tissue. Human organs grown in animals for transplant are already being designed. New types of creature may appear; creatures to marvel at. If humanity can find no peer among the stars, it could create new intelligences on earth. The genetic difference between man and chimp is small; new sentient species are not inconceivable.

All this will be made possible by genetics. But, at the same time, the preeminence of the gene will fade away. Genes have lost their privileged position as the carriers of information. Biological information will be stored in minds and computers as well as in genes, and the genes will become just one of the many means of manipulating the world, appropriate for some things and not for others, just like therapeutic proteins...

What was once unique to genes is now in humanity's grip. That grip could soon have all the power that has at times been attributed to genes and more. The same intelligence will be able to shape the gene and the environment, which between them make all organisms what they are. The control of biological information on this scale — of the raw data and the way that it is processed — means the control of biology, of life itself." (*The Economist*, February 25, 1995.)

NOTES PART THREE

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PART FOUR: ORDER OUT OF CHAOS

16. DOES MATHEMATICS REFLECT REALITY?

The fact that our subjective thought and the objective world are subject to the same laws, and hence, too, that in the final analysis they cannot contradict each other in their results, but must coincide, governs absolutely our whole theoretical thought. (Engels)

The content of “pure” mathematics is ultimately derived from the material world. The idea that the truths of mathematics are a special kind of knowledge that is inborn or of divine inspiration does not bear serious examination. Mathematics deals with the quantitative relations of the real world. Its so-called axioms only appear to be self-evident to us because they are the product of a long period of observation and experience of reality. Unfortunately, this fact seems to be lost on many present-day theoretical mathematicians who delude themselves into thinking that their “pure” subject has nothing to do with the crude world of material things. This is a clear example of the negative consequences of carrying the division of labor to the extreme.

From Pythagoras onwards, the most extravagant claims have been made on behalf of mathematics, which has been portrayed as the queen of the sciences, the magic key opening all doors of the universe. Breaking free from all contact with the physical world, mathematics appeared to soar into the heavens, where it acquired a god-like existence, obeying no rule but its own. Thus, the great mathematician Henri Poincaré, in the early years of this century, could claim that the laws of science did not relate to the real world at all, but represented

arbitrary conventions destined to promote a more convenient and “useful” description of the corresponding phenomena. Certain theoretical physicists now openly state that the validity of their mathematical models does not depend upon empirical verification, but on the aesthetic qualities of their equations.

The theories of mathematics have been, on the one side, the source of tremendous scientific advance, and, on the other, the origin of numerous errors and misconceptions which have had, and are still having profoundly negative consequences. The central error is to attempt to reduce the complex, dynamic and contradictory workings of nature to static, orderly quantitative formulae. Nature is presented in a formalistic manner, as a single-dimensional point, which becomes a line, which becomes a plane, a cube, a sphere, and so on. However, the idea that pure mathematics is absolute thought, unsullied by contact with material things is far from the truth. We use the decimal system, not because of logical deduction or “free will,” but because we have ten fingers. The word “digital” comes from the Latin word for fingers. And to this day, a schoolboy will secretly count his material fingers beneath a material desk, before arriving at the answer to an abstract mathematical problem. In so doing, the child is unconsciously retracing the way in which early humans learned to count.

The material origins of the abstractions of mathematics were no secret to Aristotle: “The mathematician,” he wrote, “investigates abstractions. He eliminates all sensible qualities like weight, density, temperature, etc., leaving only the quantitative and continuous (in one, two or three dimensions) and its essential attributes.” Elsewhere he says: “Mathematical objects cannot exist apart from sensible (i.e., material) things.” And “We have no experience of anything which consists of lines or planes or points, as we should have if these things were material substances, lines, etc., may be prior in definition to body, but they are not on that account prior in substance.”¹

The development of mathematics is the result of very material human needs. Early man at first had only ten number sounds, precisely because he counted, like a small child, on his fingers. The exception were the Mayas of Central America who had a numerical system based on twenty instead of ten, probably because they counted their toes as well as their fingers. Living in a simple hunter-gatherer society, without money or private property, our ancestors had no need of large numbers. To convey a number larger than ten, he merely combined some of the ten sounds connected with his fingers. Thus, one more than ten is expressed by “one-ten,” (undecim, in Latin, or ein-lifon — “one

over” — in early Teutonic, which becomes eleven in modern English). All the other numbers are only combinations of the original ten sounds, with the exception of five additions — hundred, thousand, million, billion and trillion.

The real origin of numbers was already understood by the great English materialist philosopher of the 17th century Thomas Hobbes: “And it seems, there was a time when those names of number were not in use; and men were fayne to apply their fingers of one or both hands, to those things they desired to keep account of; and that thence it proceeded, that now our numerall words are but ten, in any Nation, and in some but five, and then they begin again.” ²

Alfred Hooper explains: “Just because primitive man invented the same number of number-sounds as he had fingers, our number-scale today is a decimal one, that is, a scale based on ten, and consisting of endless repetitions of the first ten basic number-sounds...Had men been given twelve fingers instead of ten, we should doubtless have a duo-decimal number-scale today, one based on twelve, consisting of endless repetitions of twelve basic number-sounds.” ³ In fact, a duodecimal system has certain advantages in comparison to the decimal one. Whereas ten can only be exactly divided by two and five, twelve can be divided exactly by two, three, four and six.

The Roman numerals are pictorial representations of fingers. Probably the symbol for five represented the gap between thumb and fingers. The word “calculus” (from which we derive “calculate”) means “pebble” in Latin, connected with the method of counting stone beads on an abacus. These, and countless other examples serve to illustrate how mathematics did not arise from the free operation of the human mind, but is the product of a lengthy process of social evolution, trial and error, observation and experiment, which gradually becomes separated out as a body of knowledge of an apparently abstract character. Similarly, our present systems of weights and measures have been derived from material objects. The origin of the English unit of measurement, the foot, is self-evident, as is the Spanish word for an inch, “pulgada,” which means a thumb. The origin of the most basic mathematical symbols + and – has nothing to do with mathematics. They were the signs used in the Middle Ages by the merchants to calculate excess or deficiency of quantities of goods in warehouses.

The need to build dwellings to protect themselves from the elements forced early humans to find the best and most practical way of cutting wood so that their ends fitted closely together. This meant the discovery of the right angle and the carpenters’ square. The need to build a house on level ground led to the

invention of the kind of leveling instrument depicted in Egyptian and Roman tombs, consisting of three pieces of wood joined together in an isosceles triangle, with a cord fastened at the apex. Such simple practical tools were used in the construction of the pyramids. The Egyptian priests accumulated a huge body of mathematical knowledge derived ultimately from such practical activity.

The very word “geometry” betrays its practical origins. It means simply “earth-measurement.” The virtue of the Greeks was to give a finished theoretical expression to these discoveries. However, in presenting their theorems as the pure product of logical deduction, they were misleading themselves and future generations. Ultimately, mathematics derives from material reality, and, indeed, could have no application if this were not the case. Even the famous theorem of Pythagoras, known to every school pupil, that a square drawn on the longest side of a right triangle is equal to the sum of the squares drawn on the other two sides, had been already worked out in practice by the Egyptians.

Contradictions in Mathematics

Engels, and before him Hegel, pointed to the numerous contradictions that abound in mathematics. This was always the case, despite the claims of perfection and almost papal infallibility made by mathematicians for their “sublime science.” This fashion was started by the Pythagoreans, with their mystical conception of Number, and the harmony of the universe. Very soon, however, they found out that their harmonious and orderly mathematical universe was plagued with contradictions, the solution of which drove them to despair. For example, they found that it was impossible to express the length of the diagonal of a square in numbers.

The later Pythagoreans discovered that there were many numbers, like the square root of two, which could not be expressed in numbers. It is an “irrational number.” But although the square root of two cannot be expressed as a fraction, it is useful to find the length of the side of a triangle. Present-day mathematics contains a veritable menagerie of such strange animals, still untamed, despite all efforts to domesticate them, but which, once accepted for what they are, render valuable services. Thus we have irrational numbers, imaginary numbers, transcendental numbers, transfinite numbers, all displaying strange and contradictory features, and all indispensable to the workings of modern science.

The mysterious ¹ (pi) was well known to the ancient Greeks, and generations of schoolchildren have learned to identify it as the ratio between the

circumference and diameter of a circle. Yet, strangely, its exact value cannot be found. Archimedes calculated its approximate value by a method known as “exhaustion.” It was between 3.14085 and 3.14286. But if we try to write down the exact value, we get a strange result: $\pi = 3.14159265358979323846264338327950\dots$ and so on ad infinitum. Pi (π) which is now known as a transcendental number, is absolutely necessary to find the circumference of a circle, but cannot be expressed as the solution to an algebraic equation. Then we have the square root of minus one, which is not an arithmetical number at all. Mathematicians refer to it as an “imaginary number,” since no real number, when multiplied by itself, can give the result of minus one, because two minuses give a plus. A most peculiar creature, this — but not a figment of the imagination, despite its name. In *Anti-Dühring*, Engels points out that:

“It is a contradiction that a negative magnitude should be the square of anything, for every negative magnitude multiplied by itself gives a positive square. The square root of minus one is therefore not only a contradiction, but even an absurd contradiction, a real absurdity. And yet $\sqrt{-1}$ is in many cases a necessary result of correct mathematical operations. Furthermore, where would mathematics — lower or higher — be, if it were prohibited from operating with $\sqrt{-1}$?”⁴ Engels’ remark is even more true today. This contradictory combination of plus and minus plays an absolutely crucial role in quantum mechanics, where it appears in a whole host of equations, which are fundamental to modern science.

That this mathematics involves startling contradictions is not open to doubt. Here is what Hoffman has to say about it:

“That such a formula should have any connection with that world of strict experiment which is the world of physics is in itself difficult to believe. That it was to be the deep foundation of the new physics, and that it should actually probe more profoundly than anything before towards the very core of science and metaphysics is as incredible as must once have seemed the doctrine that the earth is round.”⁵

Nowadays, the use of the so-called “imaginary” numbers is taken for granted. The square root of minus one is used for a whole range of necessary operations, such as the construction of electrical circuits. Transfinite numbers, in turn, are needed to understand the nature of time and space. Modern science, and particularly quantum mechanics, could not manage without the use of mathematical concepts which are frankly contradictory in character. Paul Dirac,

one of the founders of quantum mechanics, discovered the “Q” numbers, which defy the laws of ordinary mathematics which state that a multiplied by b is the same thing as b multiplied by a .

Does the Infinite Exist?

The idea of the infinite seems difficult to grasp, because, at first sight, it is beyond all human experience. The human mind is accustomed to dealing with finite things, reflected in finite ideas. Everything has a beginning and an end. This is a familiar thought. But what is familiar is not necessarily true. The history of mathematical thought has some highly instructive lessons on this score. For a long time, mathematicians, at least in Europe, sought to banish the concept of infinity. Their reasons for so doing are obvious enough. Apart from the evident difficulty in conceptualizing infinity, in purely mathematical terms it involves a contradiction. Mathematics deals with definite magnitudes. Infinity by its very nature cannot be counted or measured. This means that there is a real conflict between the two. For that reason, the great mathematicians of ancient Greece avoided infinity like the plague. Despite this, from the beginnings of philosophy, men speculated about infinity. Anaximander (610-547 B.C.) took it as the basis of his philosophy.

The paradoxes of Zeno (c. 450 B.C.) point to the difficulty inherent in the idea of infinitesimal quantity as a constituent of continuous magnitudes by attempting to prove that movement is an illusion. Zeno “disproved” motion in different ways. He argued that a body in motion, before reaching a given point, must first have traveled half the distance. But before this, it must have traveled half of that half, and so on ad infinitum. Thus, when two bodies are moving in the same direction, and the one behind at a fixed distance from the one in front is moving faster, we assume that it will overtake the other. Not so, says Zeno. “The slower one can never be overtaken by the quicker.” This is the famous paradox of Achilles the Swift. Imagine a race between Achilles and a tortoise. Suppose that Achilles can run ten times faster than the tortoise which has 1000 meters start. By the time Achilles has covered 1000 meters, the tortoise will be 100 meters ahead; when Achilles has covered that 100 meters, the tortoise will be one meter ahead; when he covers that distance, the tortoise will be one tenth of a meter ahead, and so on to infinity.

Zeno’s paradoxes do not prove that movement is an illusion, or that Achilles, in practice, will not overtake the tortoise, but they do reveal brilliantly

the limitations of the kind of thinking now known as formal logic. The attempt to eliminate all contradiction from reality, as the Eleatics did, inevitably leads to this kind of insoluble paradox, or antinomy, as Kant later called it. In order to prove that a line could not consist of an infinite number of points, Zeno claimed that, if it were really so, then Achilles would never overtake the tortoise. There really is a logical problem here. As Alfred Hooper explains:

“This paradox still perplexes even those who know that it is possible to find the sum of an infinite series of numbers forming a geometrical progression whose common ratio is less than 1, and whose terms consequently become smaller and smaller and thus ‘converge’ on some limiting value.”⁶

In fact, Zeno had uncovered a contradiction in mathematical thought which would have to wait two thousand years for a solution. The contradiction relates to the use of the infinite. From Pythagoras right up to the discovery of the differential and integral calculus in the 17th century, mathematicians went to great lengths to avoid the use of the concept of infinity. Only the great genius Archimedes approached the subject, but still avoided it by using a roundabout method. The early atomists, starting with Leukippus, who may have been a pupil of Zeno, stated that the atoms “indivisible and infinite in number, move about ceaselessly in empty space, of infinite extent.”

Modern physics accepts that the number of instants between two seconds is infinite, just as the number of instants in a span of time with neither beginning nor end. The universe itself consists of an infinite chain of cause and effect, ceaselessly changing, moving and developing. This has nothing in common with the crude and one-sided notion of infinity contained in the infinite series of numbers in simple arithmetic, in which “infinity” always “starts” with the number one! This is what Hegel called “Bad Infinity.”

The greatest of Greek mathematicians, Archimedes (287-212 B.C.) made effective use of indivisibles in geometry, but considered the idea of infinitely large and small as without logical foundation. Likewise, Aristotle argued that, since a body must have form, it must be bounded, and therefore cannot be infinite. While accepting that there were two kinds of “potential” infinities — successive addition in arithmetic (infinitely large), and successive subdivision in geometry (infinitely small) — he nevertheless polemicized against geometers who held that a line segment is composed of infinitely many fixed infinitesimals, or indivisibles.

This denial of the infinite constituted a real barrier to the development of classical Greek mathematics. By contrast, the Indian mathematicians had no

such scruples and made great advances, which, via the Arabs, later entered Europe. The attempt to banish contradiction from thought, in accordance with the rigid schemas of formal logic held back the development of mathematics. But the adventurous spirit of the Renaissance opened men's minds to new possibilities which were, in truth, infinite. In his book *The New Science* (1638), Galileo pointed out that every integer (whole number) has only one perfect square, and every perfect square is the square of only one positive integer. Thus, in a sense, there are just as many perfect squares as there are positive integers. This immediately leads us into a logical contradiction. It contradicts the axiom that the whole is greater than any of its parts, inasmuch as not all the positive integers are perfect squares, and all the perfect squares form part of all the positive integers.

This is only one of the numerous paradoxes which have plagued mathematics ever since the Renaissance when men began to subject their thoughts and assumptions to a critical analysis. As a result of this, slowly, and in the teeth of stubborn resistance from conservative minds, one by one the supposedly unassailable axioms and "eternal truths" of mathematics have been overthrown. We arrive at the point where the entire edifice has been shown to be unsound and in need of a thoroughgoing reconstruction on more solid, yet more flexible foundations, which are already in the process of being laid, and which will inevitably have a dialectical character.

The Calculus

Many of the so-called axioms of classical Greek mathematics were already undermined by the discovery of the differential and integral calculus, the greatest breakthrough in mathematics since the Middle Ages. It is an axiom of geometry that straight and curved are absolute opposites, and that the two are incommensurable, that is, the one cannot be expressed in terms of the other. Yet, in the last analysis, straight and curved in the differential calculus are regarded as equal. As Engels points out, the basis for this was laid a long time before it was elaborated by Leibniz and Newton: "The turning-point in mathematics was Descartes' variable magnitude. With that came motion and hence dialectics in mathematics, and at once, too, of necessity the differential and integral calculus, which moreover immediately begins, and which on the whole was completed by Newton and Leibniz, not discovered by them."⁷

The discovery of the calculus opened up a whole new horizon for mathematics and science in general. Once the old taboos and prohibitions were lifted, mathematicians were free to investigate entirely new areas. But they made use of infinitely large and small numbers uncritically, without considering their logical and conceptual implications. The use of infinitely small and great quantities was regarded as a kind of “useful fiction,” which, for some reason which was not at all clear, always gave the correct result. In the section on Quantity in the first volume of *The Science of Logic*, Hegel points out that, while the introduction of the mathematical infinite opened up new horizons for mathematics, and led to important results, it remained unexplained, because it clashed with the existing traditions and methods:

“But in the method of the mathematical infinite mathematics finds a radical contradiction to that very method which is characteristic of itself, and on which it rests as a science. For the calculation of the infinite admits of, and demands, modes of procedure which mathematics, when it operates with finite magnitudes, must altogether reject, and at the same time it treats these infinite magnitudes as finite Quanta, seeking to apply to the former those same methods which are valid for the latter.”⁸

The result was a long period of controversy concerning the validity of the calculus. Berkeley denounced it as in open contradiction to the laws of logic. Newton, who made use of the new method in his *Principia*, felt obliged to conceal the fact from the public, for fear of an adverse reaction. In the early 18th century, Bernard Fontenelle finally had the courage to state categorically that inasmuch as there are infinitely many natural numbers, an infinite number exists as truly as do finite numbers, and that the reciprocal of infinity is an infinitesimal. However, he was contradicted by Georges de Buffon, who rejected the infinity as an illusion. Even the great intellect of D’Alembert was incapable of accepting this idea. In the article in his *Encyclopedia on the Differential*, he denied the existence of infinity, except in the negative sense of a limit on finite quantities.

The concept of “limit” was in fact introduced in an attempt to get round the contradiction inherent in infinity. This was especially popular in the 19th century, when mathematicians were no longer prepared simply to accept the calculus unthinkingly, as the earlier generation had been content to do. The differential calculus postulated the existence of infinitesimally small magnitudes of varying orders — a first differential, a second differential, and so on to infinity. By introducing the concept of “limit” they at least created the appearance that an actual infinity was not involved. The intention was to make the idea of infinity

seem subjective, to deny it objectivity. The variables were said to be potentially infinitely small, in that they become less than any given quantity, as potentially infinite, in that they become larger than any pre-assigned magnitude. In other words, “as big or small as you like!” This sleight of hand did not remove the difficulty, but only provided a fig-leaf to cover up the logical contradictions involved in the calculus.

The great German mathematician Karl Frederick Gauss (1777-1855) was prepared to accept the mathematical infinite, but expressed horror at the idea of real infinity. However, his contemporary Bernhard Bolzano, setting out from Galileo’s paradox, began a serious study of the paradoxes implicit in the idea of a “completed infinite.” This work was further developed by Richard Dedekind (1813-1914) who characterized the infinite as something positive, and pointed out that, in fact, the positive set of numbers can be regarded as negative (that is, as one that is not infinite). Finally, George Cantor (1845-1918) went far beyond the definition of infinite sets and developed an entirely new arithmetic of “transfinite numbers.” Cantor’s papers, beginning in 1870, are a review of the whole history of the infinite, beginning with Democritus. Out of this, there developed a whole new branch of mathematics, based on the theory of sets.

Cantor showed that the points in an area, however large, or in a volume or a continuum of still higher dimension, can be matched against the points on a line or a segment, no matter how small it may be. Just as there can be no last finite number, so there can be no last transfinite number. Thus, after Cantor, there can be no argument about the central place of the infinite in mathematics. Moreover, his work revealed a series of paradoxes which have plagued modern mathematics, and have yet to be resolved.

All modern scientific analysis relies on the concept of continuity, that is to say, that between two points in space, there is an infinite number of other points, and also that, between any two points in time there is an infinite number of other moments. Without making these assumptions, modern mathematics simply could not function. Yet such contradictory concepts would have been indignantly rejected, or at least regarded with suspicion, by earlier generations. Only the dialectical genius of Hegel (a great mathematician incidentally) was capable of anticipating all this in his analysis of finite and infinite, space, time and motion.

Yet despite all the evidence, many modern mathematicians persist in denying the objectivity of infinity, while accepting its validity as a phenomenon of “pure” mathematics. Such a division makes no sense at all. For unless

mathematics was able to reflect the real, objective world, what use would it be? There is a certain tendency in modern mathematics (and, by extension, incredibly, in theoretical physics) to revert to idealism in its most mystical form, alleging that the validity of an equation is purely a question of its aesthetic value, with no reference to the material world.

The very fact that mathematical operations can be applied to the real world and get meaningful results indicates that there is an affinity between the two. Otherwise, mathematics would have no practical application, which is clearly not the case. The reason why infinity can be used, and must be used, in modern mathematics is because it corresponds to the existence of infinity in nature itself, which has imposed itself upon mathematics, like an uninvited guest, despite all the attempts to bar the door against it.

The reason why it took so long for mathematics to accept infinity was explained very well by Engels:

It is clear that an infinity which has an end but no beginning is neither more or less infinite than one with a beginning but no end. The slightest dialectical insight should have told Herr Dühring that beginning and end necessarily belong together, like the North Pole and the South Pole, and that if the end is left out, the beginning just becomes the end — the one end which the series has; and vice versa. The whole deception would be impossible but for the mathematical usage of working with infinite series. Because in mathematics it is necessary to start from determinate, finite terms in order to reach the indeterminate, the infinite, all mathematical series, positive and negative, must start with 1, or they cannot be used for calculation. But the logical need of the mathematician is far from being a compulsory law for the real world.⁹

Crisis of Mathematics

From our school days we are taught to look upon mathematics, with its self-evident truths “axioms” and its rigorous logical deductions as the last word in scientific exactitude. In 1900, all this seemed certain, although in the International Congress of mathematicians held that year, David Hilbert set forth a list of the 23 most significant unsolved mathematical problems. From that point things have got steadily more complicated, to the point where it is possible to talk of a real crisis in theoretical mathematics. In his widely-read book, *Mathematics: The Loss of Certainty*, published in 1980, Morris Klein describes the situation thus:

Creations of the early 19th century, strange geometries and strange algebras, forced mathematicians, reluctantly and grudgingly, to realize that mathematics proper and the mathematical laws of science were not truths. They found, for example, that several differing geometries fit spatial experience equally well. All could not be

truths. Apparently mathematical design was not inherent in nature, or if it was, man's mathematics was not necessarily the account of that design. The key to reality had been lost. This realization was the first of the calamities to befall mathematics.

The creation of these new geometries and algebras caused mathematicians to experience a shock of another nature. The conviction that they were obtaining truths had entranced them so much that they had rushed impetuously to secure these seeming truths at the cost of sound reasoning. The realization that mathematics was not a body of truths shook their confidence in what they had created, and they undertook to reexamine their creations. They were dismayed to find that the logic of mathematics was in sad shape.

At the beginning of the 20th century, they set about trying to solve the unsolved problems, remove the contradictions, and elaborate a new and foolproof system of mathematics. As Klein explains:

By 1900 the mathematicians believed they had achieved their goal. Though they had to be content with mathematics as an approximate description of nature and many even abandoned the belief in the mathematical design of nature, they did gloat over their reconstruction of the logical structure of mathematics. But before they had finished toasting their presumed success, contradictions were discovered in the reconstructed mathematics. Commonly these contradictions were referred to as paradoxes, a euphemism that avoids facing the fact that contradictions vitiate the logic of mathematics.

The resolution of the contradictions was undertaken almost immediately by the leading mathematicians and philosophers of the times. In effect four different approaches to mathematics were conceived, formulated, and advanced, each of which gathered many adherents. These foundational schools all attempted not only to resolve the known contradictions but to ensure that no new ones could ever arise, that is, to establish the consistency of mathematics. Other issues arose in the foundational efforts. The acceptability of some axioms and some principles of deductive logic also became bones of contention on which the several schools took differing positions.

The attempt to eliminate contradictions from mathematics only led to new and insoluble contradictions. The final blow was struck in 1930, when Kurt Gödel published his famous theorems, which provoked a crisis, even calling into question the fundamental methods of classical mathematics:

As late as 1930 a mathematician might perhaps have been content with accepting one or another of the several foundations of mathematics and declared that his mathematical proofs were at least in accord with the tenets of that school. But disaster struck again in the form of a famous paper by Kurt Gödel in which he proved, among other significant and disturbing results, that the logical principles accepted by the several schools could not prove the consistency of mathematics.

This, Gödel showed, cannot be done without involving logical principles so dubious as to question what is accomplished. Gödel's theorems produced a debacle. Subsequent developments brought further complications. For example, even the axiomatic-deductive method so highly regarded in the past as the approach to exact knowledge was seen to be flawed. The net effect of these newer developments was to add to the variety of possible approaches to mathematics and to divide mathematicians into an even greater number of differing factions.¹⁰

The impasse of mathematics has produced a number of different factions and schools, none of which accept the theories of the others. There are the Platonists (yes, that's right), who regard mathematics as an absolute truth ("God is a mathematician"). There are the Conceptualists, whose conception of mathematics is entirely different to that of the Platonists, but it is merely the difference between objective and subjective idealism. They see mathematics as a series of structures, patterns and symmetries which people have invented for their own purposes — in other words, mathematics has no objective basis, but is purely the product of the human mind! This theory is apparently popular in Britain.

Then we have the Formalist school, which was formed at the beginning of the 20th century, with the specific aim of eliminating contradictions from mathematics. David Hilbert, one of the founders of this school, saw mathematics as nothing more than the manipulation of symbols according to specific rules to produce a system of tautological statements, which have inner consistency, but otherwise no meaning whatsoever. Here mathematics is reduced to an intellectual game, like chess — again a completely subjective approach. The Intuitionist school is equally determined to separate mathematics from objective reality. A mathematical formula, according to these people, is not supposed to represent anything existing independently of the act of computation itself. This has been compared to the attempt of Bohr to use the discoveries of quantum mechanics to introduce new views of physical and mathematical quantities as divorced from objective reality.

All these schools have in common an entirely idealist approach to mathematics. The only difference is that the neo-Platonists are objective idealists, who think that mathematics originated in the mind of God, and the rest — intuitionists, formalists and conceptualists — believes that mathematics is a subjective creation of the human mind, devoid of any objective significance. This, then, is the sorry spectacle presented by the main schools of mathematics in the last decade of the 20th century. But it is not the end of the story.

Chaos and Complexity

In recent years, the limitations of mathematical models to express the real workings of nature have been the subject of intense discussion. Differential equations, for example, represent reality as a continuum, in which changes in time and place occur smoothly and uninterruptedly. There is no room here for sudden breaks and qualitative changes. Yet these actually take place in nature. The discovery of the differential and integral calculus in the 18th century represented a great advance. But even the most advanced mathematical models are only a rough approximation to reality, valid only within certain limits. The recent debate on chaos and anti-chaos has centered on those areas involving breaks in continuity, sudden “chaotic” changes which cannot be adequately conveyed by classical mathematical formulae.

The difference between order and chaos has to do with linear and non-linear relationships. A linear relationship is one that is easy to describe mathematically: it can be expressed in one form or another as a straight line on a graph. The mathematics may be complex, but the answers can be calculated and can be predicted. A non-linear relationship, however, is one that cannot easily be resolved mathematically. There is no straight line graph that will describe it. Non-linear relationships have been historically difficult or impossible to resolve and they have been often ignored as experimental error. Referring to the famous experiment with the pendulum, James Gleick writes that the regularity Galileo saw was only an approximation. The changing angle of the body’s motion creates a slight non-linearity in the equations. At low amplitudes, the error is almost non-existent. But it is there. To get his neat results, Galileo also had to disregard non-linearities that he knew of: friction and air resistance.

Much of classic mechanics is built around linear relationships which are abstracted from real life as scientific laws. Because the real world is governed by non-linear relationships, these laws are often no more than approximations which are constantly refined through the discovery of “new” laws. These laws are mathematical models, theoretical constructions whose only justification lies in the insight they give and their usefulness in controlling natural forces. In the last twenty years the revolution in computer technology has transformed the situation by making non-linear mathematics accessible. It is for this reason that it has been possible, in a number of quite separate faculties and research establishments, for mathematicians and other scientists to be able to do the sums for “chaotic” systems where they could not be done in the past.

James Gleick's book *Chaos, Making a New Science* describes how chaotic systems have been examined by different researchers using widely different mathematical models, and yet with all the studies pointing to the same conclusion: that there is "order" in what was previously thought of as pure "disorder." The story begins with studies of weather patterns, in a computer simulation, by an American meteorologist, Edward Lorenz. Using at first twelve and then later only three variables in non-linear relationships, Lorenz was able to produce in his computer a continuous series of conditions constantly changing, but literally never repeating the same conditions twice. Using relatively simple mathematical rules, he had created "chaos."

Beginning with whatever parameters Lorenz chose himself, his computer would mechanically repeat the same calculations over and over again, yet never get the same result. This "aperiodicity" (i.e., the absence of regular cycles) is characteristic of all chaotic systems. At the same time, Lorenz noticed that although his results were perpetually different, there was at least the suggestion of "patterns" that frequently cropped up: conditions that approximated to those previously observed, although they were never exactly the same. That corresponds, of course, to everyone's experience of the real, as opposed to computer-simulated weather: there are "patterns," but no two days or two weeks are ever the same.

Other scientists also discovered "patterns" in apparently chaotic systems, as widely different as in the study of galactic orbits and in mathematical modeling of electronic oscillators. In these and other cases, Gleick notes, there were "suggestions of structure amid seemingly random behavior." It became increasingly obvious that chaotic systems were not necessarily unstable, or could endure for an indefinite period. The well-known "red-spot" visible on the surface of the planet Jupiter is an example of a continuously chaotic system that is stable. Moreover, it has been simulated in computer studies and in laboratory models. Thus, "a complex system can give rise to turbulence and cohesion at the same time." Meanwhile, other scientists used different mathematical models to study apparently chaotic phenomena in biology. One in particular made a mathematical study of population changes under a variety of conditions. Standard variables familiar to biologists were used with some of the computed relationships being, as it would be in nature, non-linear. This non-linearity could correspond, for example, to a unique characteristic of the species that might define it as a propensity to propagate, its "survivability."

These results were expressed on a graph plotting the population size, on the vertical axis, against the value of non-linear components, on the horizontal. It was found that as the non-linearity became more important — by increasing that particular parameter — so the projected population went through a number of distinct phases. Below a certain crucial level, there would be no viable population and, whatever starting point, extinction would be the result. The line on the graph simply followed a horizontal path corresponding to zero population. The next phase was a steady state, represented graphically as a single line in a rising curve. This is equivalent to stable population, at a level that depended on the initial conditions. In the next phase there were two different but fixed populations, two steady states. This was shown as a branching on the graph, or a “bifurcation.” It would be equivalent in real populations to a regular periodic oscillation, in a two year cycle. As the degree of non-linearity increased again, there was a rapid increase in bifurcations, first to a condition which corresponded to four steady states (meaning a regular cycle of four years), and that very quickly afterwards it was 8, 16, 32, and so on.

Hence, within a short spread of values of the non-linear parameter, a situation had developed which, for all practical purposes, had no steady state or recognizable periodicity — the population had become “chaotic.” It was also found that if the non-linearity was increased further throughout the “chaotic” phase, there would be periods when apparent steady states returned, based on a cycle of 3 or 7 years, but in each case giving way as non-linearity increased, to further bifurcation’s representing 6, 12, and 24 year cycles in the first case, or 14, 28, and 56 year cycles in the second. Thus, with mathematical precision, it was possible to model a change from stability with either a single steady state or regular, periodic behavior, to one that was, for all measurable purposes, random or aperiodic.

This may indicate a possible resolution to debates within the field of population science between those theorists who believe that unpredictable population variations are an aberration from a “steady state norm,” and others who believe that steady state is the aberration from “chaotic norm.” These different interpretations may arise because different researchers have effectively taken a single vertical “slice” of the rising graph, corresponding to only one particular value for non-linearity. Thus, one species could have a norm of a steady or a periodically oscillating population and another could exhibit chaotic variability. These developments in biology are another indication, as Gleick explains, that “chaos is stable; it is structured.” Similar results began to be

discovered in a wide variety of different phenomena. “Deterministic chaos was found in the records of New York measles epidemics and in 200 years of fluctuations of the Canadian lynx population, as recorded by the trappers of the Hudson’s Bay Company.” In all these cases of chaotic processes, there is exhibited the “period-doubling” that is characteristic of this particular mathematical model.

Mandelbrot’s Fractals

Another one of the pioneers of chaos theory, Benoit Mandelbrot, a mathematician at IBM, used yet another mathematical technique. In his capacity as a researcher for IBM, he looked for — and found — “patterns” in a wide variety of natural “random” processes. He found, for instance, that the background “noise” that is always present in telephone transmissions, follows a pattern that is completely unpredictable, or chaotic, but is nevertheless mathematically definable. Using a computer at IBM, Mandelbrot was able to produce chaotic systems graphically, yet only using the simplest mathematical rules. These pictures, known as “Mandelbrot sets,” showed an infinite complexity, and when a computer drawing was “blown up” to show finer detail, the vast, seemingly limitless variety continued.

The Mandelbrot sets have been described as possibly the most complex mathematical object or model ever seen. Yet within its structure, there were still patterns. By repeatedly “magnifying” the scale and looking at finer and finer detail (something the computer could do indefinitely because the whole structure was based on a given set of mathematical rules) it could be seen that there were regular repetitions — similarities — at different scales. “The degree of irregularity” was the same at different scales. Mandelbrot used the expression “fractal” to describe the patterns evident within the irregularity. He was able to construct a variety of fractal shapes, by slightly altering the mathematical rules. Thus he was able to produce a computer simulation of a coast line which, at any scale (at any magnification) always exhibited the same degree of “irregularity” or “crinkliness.”

Mandelbrot compared his computer-induced systems to examples of geometries that were also fractal shapes, repeating the same pattern over and over again on different scales. In the so-called Menger Sponge, for example, the surface area within it approaches infinity, while the actual volume of the solid approaches zero. Here, it is as if the degree of irregularity corresponds to the

"efficiency" of the sponge in taking up space. That may not be as far fetched as it may sound because, as Mandelbrot showed, there are many examples of fractal geometry in nature. The branching of the wind-pipe to make two bronchial and their repeated branching right down to the level of the tiny air passages in the lungs, follows a pattern that can be shown to be fractal. In the same way it can be shown that the branching of blood vessels is fractal. In other words, there is a "self-similarity," a repeating geometric pattern of branching, at whatever scale is examined.

The examples of fractal geometry in nature are almost limitless and in his book, *The Fractal Geometry of Nature*, Mandelbrot sought to demonstrate just that. It has been found that the spectrum of the timing of a normal heart beat follows fractal laws, perhaps due to the fractal arrangement of nerve fibers in the heart muscle. The same is true of the rapid involuntary eye movements that are a feature of schizophrenia. Thus, fractal mathematics is now routinely used in a variety of scientific fields, including physiology and disciplines as widely separated as earthquake studies and metallurgy.

Yet another indications of the deterministic basis of chaos has been shown in studies of phase transitions and by the use of what mathematical modelers call "attractors." There are many examples of phase transitions. It can mean the change from the smooth "laminar" flow of a fluid to turbulent flow, the transition from solid to liquid or liquid to gas, or the change within a system from conductivity to "superconductivity." These phase transitions may have crucial consequences in technological design and construction. An aircraft, for example would lose lift if the laminar air flow over the wing became turbulent; likewise, the pressure needed to pump water will depend on whether or not the flow in the pipe is turbulent.

The use of phase-scale diagrams and attractors represents yet another mathematical device that has found a wide variety of applications in apparently random systems. As in the case of other chaos studies, there has been the discovery of common patterns, in this case "strange attractors" in a variety of research programs, including electric oscillators, fluid dynamics and even in the distribution of stars in globular clusters. All these various mathematical devices — period-doubling; fractal geometry; strange attractors — were developed at different times by different researchers to examine chaotic dynamics. But all their results point in the same direction: that there is an underlying mathematical lawfulness in what was always considered to be random.

A mathematician, Mitchell Feigenbaum, pulling a number of threads together, has developed what he has called a “universal theory” of chaos. As Gleick says “he believed that his theory expressed a natural law about systems at the point of transition between order and turbulence...his universality was not just qualitative, it was quantitative...it extended not just to patterns but to precise numbers.”

Marxists would recognize here the similarity with the dialectical law known as the law of transformation of quantity to quality. This idea describes the transition between one period of more or less gradual development, when change can be measured or “quantified,” and the next when change has been so “revolutionary,” there has been such a “leap,” that the entire “quality” of the system has been altered. Gleick’s use of the terms in a similar sense here is yet another indication of the way modern scientific theory is stumbling towards materialist dialectics.

The central point about the new science is that it deals with the world as it really is: as a constantly shifting dynamic system. Classical linear mathematics is like formal logic which deals with fixed and unchanging categories. These are good enough as approximations, but do not reflect reality. Dialectics, however, is the logic of change, of processes and as such it represents an advance on formalism. In the same way, chaos mathematics is a step forward from the rather “unreal” science that ignored uncomfortable irregularities of life.

Quantity and Quality

The idea of the transformation of quantity into quality is implicit in modern mathematics in the study of continuity and discontinuity. This was already present in the new branch of geometry, topology, invented in the early years of the 20th century by the great French mathematician, Jules Henri Poincaré (1854-1912). Topology is the mathematics of continuity. As Ian Stewart explains it: “Continuity is the study of smooth, gradual changes, the science of the unbroken. Discontinuities are sudden, dramatic: places where a tiny change in cause produces an enormous change in effect.”¹¹

The standard text-book mathematics gives a wrong impression of how the world actually is, how nature really works. “The mathematical intuition so developed,” wrote Robert May, “ill equips the student to confront the bizarre behavior exhibited by the simplest non-linear systems.”¹² Whereas elementary school geometry teaches us to regard squares, circles, triangles and parallel-

ograms as entirely separate things, in topology (“rubber-sheet geometry”), they are treated as the same. Traditional geometry teaches that the circle cannot be squared, however in topology this is not the case. The rigid lines of demarcation are broken down: a square can be turned (“deformed”) into a circle. Despite the spectacular advances of 20th century science, it is surprising to note that a large number of what would seem to be quite simple phenomena are not properly understood and cannot be expressed in mathematical terms, for example, the weather, the flow of liquids, turbulence. The shapes of classical geometry are inadequate to express the extremely complex and irregular surfaces found in nature, as Gleick points out:

Topology studies the properties that remain unchanged when shapes are deformed by twisting or stretching or squeezing. Whether a shape is square or round, large or small, is irrelevant in topology, because stretching can change those properties. Topologists ask whether a shape is connected, whether it has holes, whether it is knotted. They imagine surfaces not just in the one-, two-, and three-dimensional universes of Euclid, but in spaces of many dimensions, impossible to visualize. Topology is geometry on rubber sheets. It concerns the qualitative rather than the quantitative.¹³

Differential equations deal with the rate of change of position. This is more difficult and complex than what may appear at first sight. Many differential equations cannot be solved at all. These equations are able to describe motion, but only as a smooth change of position, from one point to another, with no sudden leaps or interruptions. However, in nature, change does not only occur in this way. Periods of slow, gradual, uninterrupted change are punctuated by sharp turns, breaks in continuity, explosions, catastrophes. This fact can be illustrated by innumerable examples from organic and inorganic nature, the history of society and of human thought. In a differential equation, time is assumed to be divided into a series of very small “time-steps.” This gives an approximation of reality, but in fact there are no such “steps.” As Heraclitus expressed it, “everything flows.”

The inability of traditional mathematics to deal with qualitative as opposed to merely quantitative change represents a severe limitation. Within certain limits, it can suffice. But when gradual quantitative change suddenly breaks down, and becomes “chaotic,” to use the current expression, the linear equations of classical mathematics no longer suffice. This is the starting point for the new non-linear mathematics, pioneered by Benoit Mandelbrot, Edward Lorenz and Mitchell Feigenbaum. Without realizing it, they were following in

the footsteps of Hegel, whose nodal line of measurement expresses the very same idea, which is central to dialectics.

The new attitude to mathematics developed as a reaction against the dead end of the existing schools of mathematics. Mandelbrot had been a member of the French school of mathematical Formalism known as the Bourbaki group, which advocated a purely abstract approach, proceeding from first principles and deducing everything from them. They were actually proud of the fact that their work had nothing to do with science or the real world. But the advent of the computer introduced an entirely new element into the situation. This is yet another example of how the development of technique conditions that of science. The vast number of computations which could be made at the press of a button made it possible to discover patterns and lawfulness where previously only random and chaotic phenomena appeared to exist.

Mandelbrot began by investigating unexplained phenomena of the natural world, like apparently random bursts of interference in radio transmissions, the flooding of the Nile, and crises of the stock exchange. He realized that the traditional mathematics could not deal adequately with such phenomena. In investigating infinity in the last century, George Cantor invented the set which is named after him. This involves a line which is divided into an infinite number of points (Cantor "dust") the total length of which is 0. Such a manifest contradiction disturbed many 19th century mathematicians, yet it served as the starting point for Mandelbrot's new theory of fractal mathematics, which played a key role in chaos theory:

"Discontinuity, bursts of noise, Cantor dusts," Gleick explains, "—phenomena like these had no place in the geometries of the past 2,000 years. The shapes of classical geometry are lines and planes, circles and spheres, triangles and cones. They represent a powerful abstraction of reality, and they inspired a powerful philosophy of Platonic harmony. Euclid made of them a geometry that lasted two millennia, the only geometry still that most people ever learn. Aristotle found an ideal beauty in them. But for understanding complexity, they turn out to be the wrong kind of abstraction."¹⁴

All science involves a degree of abstraction from the world of reality. The problem with classical Euclidean measurement, dealing with length, depth and thickness, is that it failed to capture the essence of irregular shapes that are found in the real world. The science of mathematics is the science of magnitude. The abstractions of Euclidean geometry therefore leave aside all but the quantitative side of things. Reality is reduced to planes, lines and points. However, the

abstractions of mathematics, despite the exaggerated claims made for them, remain only a rough approximation to the real world, with its irregular shapes and constant and abrupt changes. In the words of the Roman poet Horace, "You may drive out nature with a pitch-fork, yet she'll be constantly running back." James Gleick describes the difference between classical mathematics and chaos theory in the following way:

Clouds are not spheres, Mandelbrot is fond of saying. Mountains are not cones. Lightning does not travel in a straight line. The new geometry mirrors a universe that is rough, not rounded, scabrous, not smooth. It is a geometry of the pitted, pocked, and broken up, the twisted, tangled, and intertwined. The understanding of nature's complexity awaited a suspicion that the complexity was not just random, not just accident. It required a faith that the interesting feature of a lightning bolt's path, for example, was not its direction, but rather the distribution of zigs and zags. Mandelbrot's work made a claim about the world, and the claim was that such odd shapes carry meaning. The pits and tangles are more than blemishes distorting the classic shapes of Euclidean geometry. They are often the keys to the essence of a thing.¹⁵

These things were seen as monstrous aberrations by traditional mathematicians. But to a dialectician, they suggest that the unity of finite and infinite, as in the infinite divisibility of matter, can also be expressed in mathematical terms. Infinity exists in nature. The universe is infinitely large. Matter can be divided into infinitely small particles. Thus, all talk about the "beginning of the universe" and the search after the "bricks of matter" and the "ultimate particle" are based on entirely wrong assumptions. The existence of the mathematical infinite is merely a reflection of this fact. At the same time, it is a dialectical contradiction that this infinite universe consists of finite bodies. Thus, finite and infinite form a dialectical unity of opposites. The one cannot exist without the other. The question is therefore not whether the universe is finite or infinite. It is both finite and infinite as Hegel explained long ago.

The advances of modern science have permitted us to penetrate deeper and deeper into the world of matter. At each stage, an attempt has been made to "call a halt," to erect a barrier, beyond which it was allegedly impossible to go. But at each stage, the limit was overcome, revealing startling new phenomena. Every new and more powerful particle accelerators have uncovered new and smaller particles, existing in ever tinier time scales. There is no reason to suppose that the situation will be any different in relation to the quarks, which at present are being represented as the last of the particles.

Similarly, the attempt to establish the beginning of the universe and “time” will turn out to be a wild goose chase. There is no limit to the material universe, and all efforts to impose one will inevitably fail. The most encouraging thing about the new mathematics of chaos theory is that it represents a rejection of sterile abstractions and ivory-tower reductionism, and an attempt to move back towards nature and the world of everyday experience. And to the degree that mathematics reflects nature, it must begin to lose its one-sided character and acquire a whole new dimension which expresses the dynamic, contradictory, in a word, dialectical character of the real world.

17. CHAOS THEORY

Dialectical materialism, elaborated by Karl Marx and Frederick Engels, was concerned with much more than political economy: it was a world view. Nature, as Engels in particular sought to demonstrate in his writings, is proof of the correctness of both materialism and dialectics. “My recapitulation of mathematics and the natural sciences,” he wrote, “was undertaken in order to convince myself also in detail...that in nature amid the welter of innumerable changes, the same dialectical laws of motion force their way through as those which in history govern the apparent fortuitousness of events...”¹⁶

Since their day, every important new advance in scientific discovery has confirmed the Marxian outlook although scientists, because of the political implications of an association with Marxism, seldom acknowledge dialectical materialism. Now, the advent of chaos theory provides fresh backing for the fundamental ideas of the founders of scientific socialism. Up to now chaos has been largely ignored by scientists, except as a nuisance or something to be avoided. A tap drips, sometimes regularly, sometimes not; the movement of a fluid is either turbulent or not; the heart beats regularly but sometimes goes into a fibrillation; the weather blows hot or cold. Wherever there is motion that appears to be chaotic — and it is all around us — there is generally little attempt to come to terms with it from a strictly scientific point of view.

What then, are the general features of chaotic systems? Having described them in mathematical terms, what application does the mathematics have? One of the features given prominence by Gleick and others is what has been dubbed “the butterfly effect.” Lorenz, had discovered on his computer-simulated weather a remarkable development. One of his simulations was based on twelve variables, including, as we said, non-linear relationships. He found that if he started his simulation with values that were only slightly different from the

original — the difference being that one set were down to six decimal places and the second set down three places — then the “weather” produced by the computer soon veered wildly from the original. Where perhaps a slight perturbation might have been expected, there was, only after a brief period of recognizable similarity, a completely different pattern.

This means that in a complex, non-linear system, a small change in the input could produce a huge change in the output. In Lorenz’s computer world, it was equivalent to a butterfly’s wing-beat causing a hurricane in another part of the world; hence the expression. The conclusion that can be drawn from this is that, given the complexity of the forces and processes that go to determine the weather, it can never be predicted beyond a short period of time ahead. In fact, the biggest weather computer in the world, in the European center for Medium-range Weather Forecasting, does as many as 400 million calculations every second. It is fed 100 million separate weather measurements from around the world every day, and it processes data in three hours of continuous running, to produce a ten day forecast. Yet beyond two or three days the forecasts are speculative, and beyond six or seven they are worthless. Chaos theory, then, sets definite limits to the predictability of complex non-linear systems.

It is strange, nevertheless, that Gleick and others have paid so much attention to the butterfly effect, as if it injects a strange mystique into chaos theory. It is surely well established (if not accurately modeled mathematically) that in other similarly complex systems a small input can produce a large output, that an accumulation of “quantity” can be transformed to “quality.” There is only a difference of less than two per cent, for example, in the basic genetic make-up of human beings and chimpanzees — a difference that can be quantified in terms of molecular chemistry. Yet in the complex, non-linear processes that are involved in translating the genetic “code” into a living animal, this small dissimilarity means the difference between one species and another.

Marxism applies itself to perhaps the most complex of all non-linear systems — human society. With the colossal interaction of countless individuals, politics and economics constitute so complex a system that alongside it, the planet’s weather systems looks like clockwork. Nevertheless, as is the case with other “chaotic” systems, society can be treated scientifically — as long as the limits, like the weather, are understood. Unfortunately, Gleick’s book is not clear on the application of chaos theory to politics and economics. He cites an exercise by Mandelbrot, who fed his IBM computer with a hundred year’s worth of cotton prices from the New York exchange. “Each particular

price change was random and unpredictable,” he writes. “But the sequence of changes was independent of scale: curves for daily and monthly price changes matched...the degree of variation had remained constant over a tumultuous 60-year period that saw two world wars and a depression.”¹⁷

This passage cannot be taken on face value. It may be true that within certain limits, it is possible to see the same mathematical patterns that have been identified in other models or chaotic systems. But given the almost limitless complexity of human society and economics, it is inconceivable that major events like wars would not disrupt these patterns. Marxists would argue that society does lend itself to scientific study. In contrast to those who see only formlessness, Marxists see human development from the starting point of material forces, and a scientific description of social categories like classes, and so on. If the development of chaos science leads to an acceptance that the scientific method is valid in politics and economics, then it is a valuable plus. However, as Marx and Engels have always understood, theirs is an inexact science, meaning that broad trends and developments could be traced, but detailed and intimate knowledge of all influences and conditions is not possible.

Cotton prices notwithstanding, the book gives no evidence that this Marxist view is wrong. In fact, there is no explanation as to why Mandelbrot apparently saw a pattern in only 60 years' prices when he had over 100 years' of data to play with. In addition, elsewhere in the book, Gleick adds that “economists have looked for strange attractors in stock market trends but so far had not found them.” Despite the apparent limitations in the fields of economics and politics, however, it is clear that the mathematical “taming” of what were thought to be random or chaotic systems has profound implications for science as a whole. It opens up many vistas for the study of processes that were largely out of bounds in the past.

Division of Labor

One of the main characteristics of the great scientists of the Renaissance was that they were whole human beings. They had an all-rounded development, which enabled, for example, Leonardo da Vinci to be a great engineer, mathematician and mechanician, as well as an artist of genius. The same was true of Dürer, Machiavelli, Luther, and countless others, of whom Engels wrote:

“The heroes of that time were not yet in thrall to the division of labor, the restricting effects of which, with its production of one-sidedness, we so often

notice in their successors.”¹⁸ The division of labor, of course, plays a necessary role in the development of the productive forces. However, under capitalism, this has been carried to such an extreme that it begins to turn into its opposite.

The extreme division, on the one hand, between mental and manual labor means that millions of men and women are reduced to a life of unthinking drudgery on the production line, denied of any possibility to display the creativity and inventiveness which is latent in every human being. At the other extreme, we have the development of a kind of intellectual priestly caste which has arrogated to itself the sole right to the title of “guardians of science and culture.” To the degree that these people become remote from the real life of society, this has a negative effect on their consciousness. They develop in an entirely narrow, one-sided way. Not only is there an abyss separating “artists” from scientists, but the scientific community itself is riven with ever-increasing divisions between increasingly narrow specializations. It is ironic that, precisely when the “lines of demarcation” between physics, chemistry and biology are breaking down, the gulf which divides even different branches of, say, physics has become virtually unbridgeable.

James Gleick describes the situation thus:

“Few laymen realize how tightly compartmentalized the scientific community had become, a battleship with bulkheads sealed against leaks. Biologists had enough to read without keeping up with the mathematical literature — for that matter, molecular biologists had enough to read without keeping up with population biology, physicists had better ways to spend their time than sifting through the meteorology journals.”

In recent years, the advent of chaos theory is one of the indications that something is beginning to change in the scientific community. Increasingly, scientists from different fields feel that they have somehow reached a dead end. It is necessary to break out in a new direction. The birth of chaos mathematics, therefore, is a proof as Engels would have said, of the dialectical character of nature, a reminder that reality consists of whole dynamic systems, or even one whole system, and not of models (however useful) abstracted from them. What are the main features of chaos theory? Gleick describes them in the following way:

“To some physicists, chaos is a science of process rather than state, of becoming rather than being.”

“They feel that they are turning back a trend in science towards reductionism, the analysis of systems in terms of their constituent parts: quarks, chromosomes, or neutrons. They believe that they are looking for the whole.”

The method of dialectical materialism is precisely to look at “process rather than state, of becoming rather than being.” “More and more over the past decade, he’d begun to sense that the old reductionist approaches were reaching a dead end, and that even some of the hard-core physical scientists were getting fed up with mathematical abstractions that ignored the real complexities of the world. They seemed to be half-consciously groping for a new approach — and in the process, he thought, they were cutting across the traditional boundaries in a way they hadn’t done in years. Maybe centuries.”¹⁹

Because chaos is a science of whole dynamic systems, rather than separate parts, it represents, in effect, an unacknowledged vindication of the dialectical view. Up to now, scientific investigation has been too much isolated into its constituent parts. In pursuit of the “parts” the scientific specialist becomes too specialized not infrequently losing all sight of the “whole.” Experimentation and theoretical rationalizations thus became increasingly removed from reality. More than a century ago, Engels criticized the narrowness of what he called the metaphysical method, which consisted of looking at things in an isolated way, which lost sight of the whole. The starting point of the supporters of chaos theory was a reaction against precisely this method, which they call “reductionism.” Engels explained that the “reduction” of the study of nature to separate disciplines is to some extent necessary and inevitable.

“When we reflect on nature or the history of mankind or our own intellectual activity, at first we see the picture of an endless maze of connections in which nothing remains what, where and as it was, but everything moves, changes, comes into being and passes away...

“But this conception, correctly as it expresses the general character of the picture of phenomena as a whole, does not suffice to explain the details of which this picture is made up, and so long as we cannot do this, we are not clear about the whole picture. In order to understand these details we must detach them from their natural or historical connection and examine each one separately according to its nature, special causes and effects, etc.”

But as Engels warned, too great a retreat into “reductionism” can lead to an undialectical view, or a drift to metaphysical ideas.

“The analysis of nature into its individual parts, the division of the different natural processes and objects into definite classes, the study of the internal

anatomy of organic bodies in their manifold forms — these were the fundamental conditions for the gigantic strides in our knowledge of nature that have been made during the last four hundred years. But this has bequeathed us the habit of observing natural objects and processes in isolation, detached from the general context; of observing them not in their motion, but in their state of rest; not as essentially variable elements, but as constant ones; not in their life, but in their death.”²⁰

Now compare this with the following passage from Gleick’s book:

“Scientists break things apart and look at them one at a time. If they want to examine the interaction of subatomic particles, they put two or three together. There is complication enough. The power of self-similarity, though, begins at much greater levels of complexity. It is a matter of looking at the whole.”²¹

If we substitute the word “reductionism” for “the metaphysical mode of thought,” we see that the central idea is identical. Now see what conclusion Engels drew from his criticism of reductionism (“the metaphysical method”):

“But for dialectics, which grasps things and their images, ideas, essentially in their interconnection, in their sequence, their movement, their birth and death, such processes as those mentioned above are so many corroborations of its own method of treatment. Nature is the test of dialectics, and it must be said for modern natural science that it has furnished extremely rich and daily increasing materials for this test, and has thus proved that in the last analysis Nature’s process is dialectical and not metaphysical.

“But the scientists who have learnt to think dialectically are still few and far between, and hence the conflict between the discoveries made and the old traditional mode of thought is the explanation of the boundless confusion which now reigns in theoretical natural science and reduces both teachers and students, writers and readers to despair.”²²

Over one hundred years ago, old Engels accurately describes the state of the physical sciences today. This is acknowledged by Ilya Prigogine (Nobel-prize winner for chemistry 1977) and Isabelle Stengers in their book *Order Out of Chaos, Man’s New Dialogue with Nature*, where they writes the following:

To a certain extent, there is an analogy between this conflict (between Newtonian physics and the new scientific ideas) and the one that gave rise to dialectical materialism...The idea of a history of nature as an integral part of materialism was asserted by Marx and, in greater detail, by Engels. Contemporary developments in physics, the discovery of the constructive role played by irreversibility, have thus raised within the natural sciences a question that has long been asked by materialists. For

them, understanding nature meant understanding it as being capable of producing man and his societies.

Moreover, at the time Engels wrote his *Dialectics of Nature*, the physical sciences seemed to have rejected the mechanistic world view and drawn closer to the idea of an historical development of nature. Engels mentions three fundamental discoveries: energy and the laws governing its qualitative transformations, the cell as the basic constituent of life, and Darwin's discovery of the evolution of species. In view of these great discoveries, Engels came to the conclusion that the mechanistic world view was dead.²³

Despite all the wonderful advances of science and technology, there is a deep-seated feeling of malaise. An increasing number of scientists are beginning to rebel against the prevailing orthodoxies and seek new solutions to the problems facing them. Sooner or later, this is bound to result in a new revolution in science, similar to the one effected by Einstein and Planck nearly a century ago. Significantly, Einstein himself was far from being a member of the scientific establishment.

The mainstream for most of the twentieth century," Gleick remarks, "has been particle physics, exploring the building blocks of matter at higher and higher energies, smaller and smaller scale, shorter and shorter times. Out of particle physics have come theories about the fundamental forces of nature and about the origin of the universe. Yet some young physicists have grown dissatisfied with the direction of the most prestigious of sciences. Progress has begun to seem slow, the naming of new particles futile, the body of theory cluttered. With the coming of chaos, younger scientists believed they were seeing the beginnings of a course change for all of physics. The field had been dominated long enough, they felt, by the glittering abstractions of high-energy particles and quantum mechanics.

Chaos and Dialectics

It is as yet too early to form a definitive view of chaos theory. However, what is clear is that these scientists are groping in the direction of a dialectical view of nature. For example, the dialectical law of the transformation of quantity into quality (and vice versa) plays a prominent role in chaos theory:

He (Von Neumann) recognized that a complicated dynamical system could have points of instability — critical points where a small push can have large consequences, as with a ball balanced at the top of a hill.

And again:

In science as in life, it is well known that a chain of events can have a point of crisis that could magnify small changes. But chaos meant that such points were everywhere. They were pervasive.²⁴

These and many other passages reveal a striking resemblance between certain aspects of chaos theory and dialectics. Yet the most incredible thing is that most of the pioneers of “chaos” seem to have not the slightest knowledge not only of the writings of Marx and Engels, but even of Hegel! In one sense, this provides even more striking confirmation of the correctness of dialectical materialism. But in another, it is a frustrating thought that the absence of an adequate philosophical framework and methodology has been denied to science needlessly and for such a long time.

For 300 years, physics was based on linear systems. The name linear refers to the fact that if you plot such an equation on a graph, it emerges as a straight line. Indeed, much of nature appears to work precisely in this way. This is why classical mechanics is able to describe it adequately. However, much of nature is not linear, and cannot be understood through linear systems. The brain certainly does not function in a linear manner, nor does the economy, with its chaotic cycle of booms and slumps. A non-linear equation is not expressed in a straight line, but takes into account the irregular, contradictory and frequently chaotic nature of reality.

“All this makes me feel very unhappy about cosmologists who tell us that they’ve got the origins of the Universe pretty well wrapped up, except for the first millisecond or so of the Big Bang. And with politicians who assure us that not only is a solid dose of monetarism going to be good for us, but they’re so certain about it that a few million unemployed must be just a minor hiccup. The mathematical ecologist Robert May voiced similar sentiments in 1976. ‘Not only in research, but in the everyday world of politics and economics, we would all be better off if more people realized that simple systems do not necessarily possess simple dynamical properties.’”²⁵

The problems of modern science could be overcome far more easily by adopting a conscious (as opposed to an unconscious, haphazard, empirical) dialectical method. It is clear that the general philosophical implications of chaos theory are disputed by its scientists. Gleick quotes Ford, “a self-proclaimed evangelist of chaos” as saying that chaos means “systems liberated to randomly explore their every dynamic possibility...” Others refer to apparently random systems. Perhaps the best definition comes from Jensen, a theoretical physicist at Yale, who defines “chaos” as “the irregular, unpredictable behavior of deterministic, non-linear dynamical systems.”

Rather than elevate randomness to a principle of nature, as Ford seems to do, the new science does the opposite: it shows irrefutably that processes that

were considered to be random (and may still be so considered, for everyday purposes) are nevertheless driven by an underlying determinism — not the crude mechanical determinism of the 18th century but dialectical determinism.

Some of the claims being made for the new science are very grand, and with the refinement and development of methods and techniques, may well prove true. Some of its exponents go so far as to say that the 20th century will be known for three things: relativity, quantum mechanics and chaos. Albert Einstein, although one of the founders of quantum theory, was never reconciled to the idea of a non-deterministic universe. In a letter to the physicist Neils Bohr, he insisted that “God does not play dice.” Chaos theory has not only shown Einstein to be correct on this point, but even in its infancy, it is a brilliant confirmation of the fundamental world view put forward by Marx and Engels over a hundred years ago.

It is really astonishing that so many of the advocates of chaos theory, who are attempting to break with the stultifying “linear” methodology and work out a new “non-linear” mathematics, which is more in consonance with the turbulent reality of ever-changing nature, appear to be completely unaware of the only genuine revolution in logic in two millennia — the dialectical logic elaborated by Hegel, and subsequently perfected on a scientific and materialist basis by Marx and Engels. How many errors, blind alleys and crises in science could have been avoided if scientists had been equipped with a methodology which genuinely reflects the dynamic reality of nature, instead of conflicting with it at every turn!

18. THE THEORY OF KNOWLEDGE

It is the customary fate of new truths to begin as heresies and to end as superstitions. (T. H. Huxley)

The basic assumption underlying all science and rational thought in general is that the physical world exists, and that it is possible to understand the laws governing objective reality. The great majority of working scientists accept that the universe is governed by natural law, a fact pointed out by Philip Anderson:

Indeed, it's hard to imagine how science could exist if they didn't. To believe in natural law is to believe that the universe is ultimately comprehensible — that the same forces that determine the destiny of a galaxy can also determine the fall of an apple here on earth; that the same atoms that refract the light passing through a diamond can also form the stuff of a living cell; that the same electrons, neutrons, and protons that emerged from the big bang can now give rise to the human brain,

mind, and soul. To believe in natural law is to believe in the unity of nature at the deepest possible level.²⁶

The same is true of the human race in general. Every new discovery of science and technique broadens and deepens our understanding, but by so doing, also poses new challenges. Every question answered immediately raises two more questions. Like a traveller who, with growing excitement, approaches the horizon, only to discover a new one, beckoning him from afar, the process of discovery unfolds with no end in sight. Scientists delve ever deeper into the mysteries of the subatomic world, in search of the “ultimate particle.” But each time they reach the horizon with a triumphant cry, it stubbornly recedes into the distance.

It is the illusion of every epoch that it represents the ultimate peak of all human achievements and wisdom. The ancient Greeks thought that they had understood all the laws of the universe on the basis of Euclid’s geometry. Laplace thought the same in relation to Newton’s mechanics. In 1880, the chief of the Prussian patent office declared that everything that could ever be discovered had already been invented! Nowadays, scientists tend to be slightly more circumspect in their pronouncements. Even so, tacit assumptions are made that, for example, Einstein’s general relativity theory is absolutely true, and the principle of indeterminacy has a universal application.

The history of science shows how economical the human mind is. Very little is actually wasted in the process of collective learning. Even mistakes, when honestly analyzed, can play a positive role. Only when thought becomes ossified into official dogma, which treats new ideas as heresy to be prohibited and punished, is the development of thought paralyzed and even thrust back. The dismal history of science in the Middle Ages is sufficient proof of this. The search for the philosopher’s stone was based upon a mistaken hypothesis, yet the alchemists made important discoveries, and laid the basis for the development of modern chemistry. The big bang theory, with its search for a non-existent “beginning of time,” has scarcely any better scientific credentials, yet, despite this, there is no doubt about the big advances which have been, and are being, made.

As Eric J. Lerner correctly observes: “Good data, competently obtained and analyzed, is of scientific value even if the theory that inspired it is wrong. Other theorists will find uses for it that were little imagined when it was first gathered. Even in theoretical work, honest efforts to compare a theory to observation almost always prove useful regardless of the theory’s truth: a theoretician is

bound to be upset if his idea is wrong, but time won't have been wasted in ruling it out.”²⁷

The development of science proceeds through an infinite series of successive approximations. Each generation arrives at a series of fundamental generalizations about the workings of nature, which serve to explain certain observed phenomena. These are invariably considered to be absolute truths, valid for all time in “all possible worlds.” On further examination, however, they are found to be not absolute, but relative. Exceptions are discovered, which contradict the established rules, and, in turn, demand explanation, and so on ad infinitum.

The first discoveries were realization that each change of scale brought new phenomena and new kinds of behavior. For modern particle physicists, the process has never ended. Every new accelerator, with its increase in energy and speed, extends science's field of view to tinier particles and briefer time scales, and every extension seems to bring new information.²⁸

Should we therefore despair of ever achieving the whole truth? To pose the question in this way is not to understand the nature of truth and human knowledge. Thus Kant thought that the human mind could only ever know appearances. Behind the world of appearances lay the Thing-in-Itself, which we can never know. To this Hegel replied that to know the properties of a thing is to know the thing itself. There is no absolute barrier between appearance and essence. We start with the reality which presents itself to us in sense-perception, but we do not stop here. Using our intellect, we penetrate ever deeper into the mysteries of matter, passing beyond appearance to essence; from the particular to the universal; from the secondary to the fundamental; from the facts to the law.

To use the terminology which Hegel used to answer Kant, the whole history of science and of human thought in general is the process of changing the Thing-in-Itself into a Thing-for-Us. In other words, what “cannot be known” at a given stage of the development of science is eventually explored and explained. Every barrier placed in the way of thought is broken down. But in solving one problem, we immediately come up against new ones which must be solved, new challenges to be overcome. And this process will never come to an end, because the properties of the material universe are indeed infinite.

To pursue our analogy further [writes David Bohm], we may say that with regard to the totality of natural laws we never have enough views and cross-sections to give us a complete understanding of this totality. But as science progresses, and new

theories are developed, we obtain more and more views from different sides, views that are more comprehensive, views that are more detailed, etc. Each particular theory or explanation of a given set of phenomena will then have a limited domain of validity and will be adequate only in a limited context and under limited conditions. This means that any theory extrapolated to an arbitrary context and to arbitrary conditions will (like the partial views of our object) lead to erroneous predictions. The finding of such errors is one of the most important means of making progress in science.

A new theory, to which the discovery of such errors will eventually give rise, does not, however invalidate the older theories. Rather, by permitting the treatment of a broader domain in which they are inadequate and, in so doing, it helps define the conditions under which they are valid (e.g. as the theory of relativity corrected Newton's laws of motion, and thus helped to define the conditions of validity of Newton's laws as those in which the velocity is small compared with that of light). Thus, we do not expect that any causal relationships will represent absolute truths; for to do this, they will have to apply without approximation, and unconditionally. Rather, then, we see that the mode of progress of science is, and has been, through a series of progressively more fundamental, more extensive, and more accurate conceptions of the laws of nature, each of which contributes to the definition of the conditions of validity of the older conceptions (just as broader and more detailed views of our object contribute to defining the limitations of any particular view or set of views).²⁹

In his book *The Structure of Scientific Revolution*, Professor Thomas Kuhn pictures the history of science as periodic theoretical revolutions, punctuating long periods of merely quantitative change, mainly devoted to filling in details. In such "normal" periods, science operates within a given set of theories which he calls paradigms, which are unquestioned assumptions about what the world is like. Initially, the existing paradigm stimulates the development of science, providing a coherent framework for investigation. Without such an agreed framework, scientists would be forever arguing about the fundamentals. Science, no more than society, cannot live in a permanent state of revolutionary upheaval. For this very reason, revolutions are relatively rare events, both in society and science.

For a time, science is able to advance along these well-trodden paths, piling up results. But in the meanwhile, what were originally daring new hypotheses become transformed into rigid orthodoxies. If an experiment produces results that conflict with the existing theories, scientists may suppress them, because they are subversive to the existing order. Only when the anomalies build up to the point where they cannot be ignored is the ground prepared for a new scientific revolution, which overthrows the dominant theories and opens up a new period of "normal" scientific development, on a higher level.

While it is undoubtedly over-simplified, this picture of the development of science, as a broad generalization, can be accepted as true. In his book Ludwig Feuerbach, Engels explains the dialectical nature of the development of human thought, as exemplified both in the history of science and philosophy:

Truth, the cognition of which is the business of philosophy, was in the hands of Hegel no longer an aggregate of finished dogmatic statements, which, once discovered, had merely to be learned by heart. Truth lay now in the process of cognition itself, in the long historical development of science, which mounts from lower to ever higher levels of knowledge without ever reaching, by discovering so-called absolute truth, a point at which it can proceed no further, where it would have nothing more to do than to fold its hands and gaze with wonder at the absolute truth to which it had attained.

And again:

For it [dialectical philosophy] nothing is final, absolute, sacred. It reveals the transitory character of everything and in everything; nothing can endure before it except the uninterrupted process of becoming and of passing away, of endless ascendancy from the lower to the higher. And dialectical philosophy itself is nothing more than the mere reflection of this process in the thinking brain. It has, of course, also a conservative side: it recognizes that definite stages of knowledge and society are justified for their time and circumstances; but only so far. The conservatism of this mode of outlook is relative; its revolutionary character is absolute — the only absolute dialectical philosophy admits.³⁰

What Is the Scientific Method?

In the 3rd century B.C. the Greek scholar Eratosthenes read that a vertical stick, positioned in a place called Syrene, cast no shadow at midday. He then observed that in his own city, Alexandria, a vertical stick did cast a shadow. From these observations of real physical phenomena, he deduced that the earth was round. He then sent a slave to Syrene to measure the distance from Alexandria. Then, using simple geometry, he calculated the circumference of the earth. This is the real method of science in action. It is a mixture of observation, hypothesis and mathematical reasoning. Eratosthenes began with observation (both his own and that of others). Then, on the basis of this, he drew a general conclusion, the hypothesis that the earth is curved. He then made use of mathematics to give a precise form to his theory.

The brilliant achievements of Alexandrine science were eclipsed by the rise of Christianity in the Dark Ages. For centuries, the development of science was paralyzed by the spiritual dictatorship of the Church. Only by freeing itself of the influence of religion did science manage to develop. Yet by a strange quirk of

history, at the end of the 20th century determined attempts are being made to drag science backwards. All kinds of quasi-religious and mystical ideas are floating in the air. This strange phenomenon is closely related to two things. Firstly, the division of labor has been carried to such extremes that it has begun to cause serious harm. Narrow specialization, reductionism, and an almost complete divorce between the theoretical and experimental side of physics has had the most negative consequences.

Secondly, there has been no adequate philosophy which could help to point science in the right direction. The philosophy of science is in a mess. This is not surprising, because the prevailing “philosophy of science” — or rather the philosophical sect of logical positivism which set itself up in this capacity — is least of all able to help science out of its difficulties. On the contrary, it has made matters worse. In recent decades, we have seen a growing tendency in theoretical physics to approach the phenomena of the natural world from an excessively abstract and mathematical standpoint. This is clearly the case in the arbitrary attempt to reconstruct an alleged beginning of the universe. As Anderson pointed out in an article written in 1972:

The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe. In fact, the more the elementary particles physicists tell us about the nature of the fundamental laws, the less relevance they seem to have to the very real problems of the rest of science, much less society.³¹

In recent decades the prejudice has become deeply rooted that “pure” science, especially theoretical physics is the product of abstract thought and mathematical deduction alone. As Eric Lerner explains, Einstein was partly responsible for this tendency. Unlike earlier theories, such as Maxwell’s laws of electromagnetism, or Newton’s laws of gravity, which were firmly based on experiment, and soon confirmed by hundreds of thousands of independent observations, Einstein’s theories were initially confirmed on the basis of only two — the deflection of starlight by the sun’s gravitational field and a slight deviation in the orbit of Mercury. The fact that relativity theory was subsequently shown to be correct has led others, possibly not quite up to Einstein’s level of genius, to assume that this is the way to proceed. Why bother with time-consuming experiments and tedious observations? Indeed, why depend upon the evidence of the senses at all, when we can get straight to the truth through the method of pure deduction?

We must remind ourselves that the great breakthrough in science came in the Renaissance, when it separated itself from religion, and began to base itself upon observation and experiment, setting out from the real material world, and always returning to it. In the 20th century, however, there has been a partial regression to idealism, both Platonism and still worse, to the subjective idealism of Berkeley and Hume. For all his unquestioned genius, Einstein was unable to free himself from this trend, although he frequently recoiled against the consequences that flowed from it. It is to his credit, for example, that he conducted a stubborn rearguard action against the subjective idealist interpretation of quantum mechanics put forward by Heisenberg.

Like many scientists, Einstein did not feel at home with philosophy, and honestly confessed that great scientists tend to make poor philosophers of science. Nevertheless, he himself made a number of pronouncements of a philosophical or semi-philosophical character, which, given his colossal prestige, were bound to be taken seriously by many scientists — with some very unfortunate results. In 1934, for example, he wrote:

The theory of relativity is a fine example of the fundamental character of the modern development of theoretical science. The hypotheses with which it starts are becoming steadily more abstract and remote from experience. The theoretical scientist is compelled in an increasing degree to be guided by purely mathematical, formal considerations in his search for a theory, because the physical experience of the experimenter cannot lift him into the regions of highest abstraction. The predominantly inductive methods appropriate to the youth of science are giving place to tentative deduction.³²

In point of fact, it is not true that Einstein arrived at his theories through a process of pure reasoning and deduction. As he himself states in his *Essays in Science*, his theory of special relativity was derived from Maxwell's work on electricity and magnetism, which, in turn, was based on the work of Faraday, with its solid experimental foundations. Only after 1915, when he turned to cosmology did Einstein turn to the method of abstract deduction to obtain his results. Here he departed from the established method by taking as his fundamental hypothesis an assumption which was contradicted by observation: the notion that the universe as a whole is homogeneous (evenly spread throughout space).

Setting out from this proposition, Einstein used his general theory of relativity to prove that space is finite. According to this view, the greater the mass of a given density, the more it "curves space." A sufficiently large mass will lead to a situation where space curves round on itself altogether, thus producing

a “closed universe.” This marked, in effect, a regression to the mediaeval world outlook of a finite universe, previously rejected as unscientific. However, even in 1915, there was sufficient evidence to show that the universe was not homogeneous. The theory collided with the facts established by observation. It is no coincidence that Einstein’s search for a unified theory of gravitation and electromagnetism during his last thirty years ended in failure, as he himself admitted.

Limits of Empiricism

Real philosophy ended with Hegel. Since then, we have seen only a tendency to repeat old ideas, occasionally a filling out of this or that detail, but no real breakthrough, no great new idea. This is hardly surprising. The unprecedented advances of science over the past hundred years makes philosophy in the old sense of the word redundant. There is very little point in speculating about the nature of the universe, when we are in a position to uncover its secrets with the aid of ever more powerful telescopes, space probes, computers and particle accelerators. Just as the debate about the nature of the solar system was decided by Galileo’s telescope, so the advances in technique will settle the question of the history of the universe, only to pose new questions for future generations to solve.

“As soon as each separate science is required to clarify its position in the great totality of things and of our knowledge of things, a special science dealing with this totality is superfluous,” wrote Engels. “All that remains in an independent state from all earlier philosophy is the science of thought and its laws — formal logic and dialectics. Everything else merges into the positive science of nature and history.”³³

Yet philosophy still has a role to play, in the only two areas left to it — formal logic and dialectics. Science, as we have seen, is not merely concerned with accumulating facts. It still requires the active intervention of thought, which alone can discover the inner meaning of the facts, their lawfulness. It is still necessary to make hypotheses, which can guide our investigations along the most fruitful channels, to grasp the real interrelations between apparently unrelated phenomena, to derive order from chaos. This requires training and a thorough knowledge of the history of both science and philosophy. As the American philosopher George Santayana put it, “He who does not learn from history is doomed to repeat it.” One of the most pernicious consequences of the

influence of logical positivism in 20th century science is that all the great schools of the past were treated like a dead dog. Now we see where this attitude leads us. Those who haughtily dismissed “metaphysics” have been punished for their pride. At no time in the history of science has mysticism been so rampant as now.

The purely empirical school of thought inevitably leads to this, as Engels pointed out long ago:

Exclusive empiricism, which at most allows itself thinking in the form of mathematical calculation, imagines that it operates only with undeniable facts. In reality, however, it operates predominantly with traditional notions, with the largely obsolete products of thought of its predecessors, and such are positive and negative electricity, the electric force of separation, the contact theory. These serve it as the foundation of endless mathematical calculations in which, owing to the strictness of the mathematical formulation, the hypothetical nature of the premises gets comfortably forgotten. This kind of empiricism is as credulous towards the results of the thought of its predecessors as it is skeptical in its attitude to the results of contemporary thought. For it even the experimentally established facts have gradually become inseparable from their traditional interpretations...They have to resort to all kinds of subterfuges and untenable expedients, to the glossing over of irreconcilable contradictions, and thus finally land themselves into a medley of contradictions from which they have no escape.³⁴

It is impossible for scientists to remain aloof from society, on the grounds that they are purely impartial. None of us live in a vacuum. As the American geneticist Theodosius Dobzhansky says:

Scientists often have a naïve faith that if only they could discover enough facts about a problem, these facts would somehow arrange themselves in a compelling and true solution. The relation between scientific discovery and popular belief is not, however, a one-way street. Marxists are more right than wrong when they argue that the problems scientists take up, the way they go about solving them, and even the solutions they are inclined to accept, are conditioned by the intellectual, social, and economic environments in which they live and work.³⁵

It is sometimes asserted that Marx and Engels considered the dialectic to be some kind of Absolute — the last word in human knowledge. Such a notion is a self-evident contradiction. The Marxian dialectic differs from the Hegelian in two fundamental ways. Firstly, it is a materialist philosophy, and therefore derives its categories from the world of physical reality. Nature is infinite, not closed. Likewise, truth itself is endless and cannot be summed up in a single all-embracing system. The negation of the negation, as Engels explains, is a kind of spiral of development — an open-ended system, not a closed circle. That is the

second fundamental difference with the Hegelian philosophy, which ultimately contradicted itself by attempting to express the dialectic as a closed and absolute System.

Marx and Engels worked out the outline of a new dialectical method, the usefulness of which was brilliantly shown in the three volumes of *Capital*. But the enormous advances of 20th century science provides ample material with which to fill out, develop and extend the content of dialectics. The further evolution of chaos and complexity theory can provide the basis for such a development, which would be of immense benefit to both the natural and social sciences. We cannot therefore say that dialectical materialism will not in the future be overtaken by some new and more satisfactory mode of thinking. But we can certainly say that up to the present time, it is the most advanced, comprehensive and flexible method of scientific analysis available. Let Engels speak for himself on this subject:

Further, if no philosophy as such is needed any longer, then no system, not even a natural system of philosophy, is needed any longer either. The recognition of the fact that all the processes of nature are systematically interconnected drives science on to prove this systematic interconnection throughout, both in general and in detail. But an adequate, exhaustive scientific exposition of this interconnection, the formation of an exact mental image of the world system in which we live, remains impossible for us, as it does for all times. If at any epoch in the development of mankind such a final, definitive system of the interconnections within the world — physical as well as mental and historical — were constructed, this would mean that the realm of human knowledge had reached its limit, and that further historical development would be cut short from the moment when society had been brought into accord with that system — which would be an absurdity, pure nonsense.

Mankind therefore finds itself faced with a contradiction: on the one hand, it has to gain an exhaustive knowledge of the world system in all its interconnections, and on the other hand, this task can never be completely fulfilled because of the nature both of men and of the world system. But this contradiction not only lies in the nature of the two factors — the world and man — it is also the main lever of all intellectual advance, and constantly finds its solution, day by day, in the endless progressive development of humanity, just as for example mathematical problems find their solution in an infinite series or continued fractions. Actually, each mental image of the world system is and remains limited, objectively by the historical situation and subjectively by its author's physical and mental constitution.³⁶

Prejudice Against Dialectics

Modern science furnishes an abundance of material which completely confirms Engels' assertion that "in the last analysis, nature works dialectically."

The discoveries of science in the hundred years since Engels died completely confirms this view.

When we reflect on Nature, or the history of mankind, or our own intellectual activity," Engels wrote, "the first picture presented to us is of an endless maze of relations and interactions, in which nothing remains what, where and as it was, but everything moves, changes, comes into being and passes out of existence. This primitive, naïve, yet intrinsically correct conception of the world was that of ancient Greek philosophy, and was first clearly formulated by Heraclitus: everything is and also is not, for everything is in flux, is constantly changing, constantly coming into being and passing away.³⁷

Let us compare this to another quotation from Hoffmann:

In the world of quantum, particles are incessantly appearing and disappearing. What we would think of as empty space is a teeming, fluctuating nothingness, with photons appearing from nowhere and vanishing almost as soon as they were born, with electrons frothing up for brief moments from the monstrous ocean to create evanescent electron-proton pairs and sundry other particles adding to the confusion.³⁸

The rise of chaos and complexity theory indicates a welcome reaction against the stultifying reductionism of the past. Yet very little attention has been paid to the pioneering work of Hegel, Marx and Engels. This astonishing fact is largely to be explained by the widespread prejudice against dialectics, partly as a reaction against the mystical way that dialectics was presented by the idealist school after Hegel's death, but mainly because of its connection with Marxism. Hegel's dialectics have been described as the "algebra of revolution." If the law of quantity and quality is accepted as valid for chemistry and physics, the next step would be to apply it to existing society, with most unfortunate consequences for the defenders of the status quo.

The scientific writings of Marx and Engels cannot be separated from their revolutionary theory of history in general (historical materialism), and their analysis of the contradictions of capitalism. There are evidently not very popular with those who currently possess a monopoly of economic and political power, and who control, not only the newspapers and television companies, but also hold in their hands the purse-strings which determine the fate of universities, research-projects, and academic careers. Is it surprising that dialectical materialism is a taboo subject, which is systematically passed over in silence, except when it is denounced as unscientific mumbo-jumbo, by people who have clearly never read a single line of Marx or Engels? True, a small number of brave souls have raised the question of the contribution of Marxism to the philosophy

of science, but even then, such mentions are frequently hedged round with all kinds of qualifications, aiming to show that dialectics may be valid for a given field of science, but cannot be accepted as a general proposition.

Nowadays, the idea of change, of evolution, has deeply penetrated the popular consciousness. But evolution is generally understood as a slow, gradual, uninterrupted process. As Trotsky put it, "Hegel's logic is the logic of evolution. Only one must not forget that the concept of 'evolution' itself has been completely corrupted and emasculated by university professors and liberal writers to mean peaceful 'progress.'"

In politics, this common prejudice finds its expression in the theory of reformist gradualism, where today is better than yesterday and tomorrow will be better than today. Sadly, human history in general, and the history of the 20th century in particular, provides precious little comfort for the supporters of this tranquilizing view of the social process. History knows long periods of gradual change but this is by no means a continuous and smooth process. It is interrupted by all kinds of explosions and catastrophes: wars, economic crises, revolutions and counter-revolutions. To deny this is to deny what everyone knows to be true. So how do we regard these phenomena? As sudden, inexplicable outbreaks of collective madness? As accidental "deviations" from the gradualist "norm"? Or, on the contrary, are they to be seen as an integral part of the process of social development — not accidents but the necessary outcome of tensions and stresses that build up gradually and unseen within society and which, sooner or later, must force their way to the surface, just as the pressures that accumulate along a fault-line in the earth's crust result in an earthquake?

Any attempt to banish contradiction from nature, to smooth out its rough edges, to subject it to the neat rules of formal logic, as the gardeners at Versailles subjected rude nature to the rules of classical geometry, is doomed to fail. Such efforts may well have a soothing effect upon the nerves, but will prove to be utterly useless to arrive at an understanding of the real world. And what is true for inanimate and animate nature is also true for the history of human society itself, despite the stubborn attempts to demonstrate the contrary. The history of society reveals the self-same tendencies — the inner contradictions that impel development; the rise and fall of different socioeconomic systems; the long periods of gradual "evolutionary" change, punctuated by sudden upheavals, wars and revolutions, which stand at the crossroads of every great historical development. Are such striking phenomena merely to be shrugged off as accidents, temporary and unfortunate deviations from the alleged evolutionary

“norm”? Or irrefutable proof of the stupidity or inherent wickedness of human beings?

If this is the case, then all attempts to arrive at a rational understanding of human development must be abandoned. We are compelled to echo the opinion of Edward Gibbon, author of *The Decline and Fall of the Roman Empire* who described history as “little more than the register of the crimes, follies, and misfortunes of mankind.” But if, as we firmly believe, human history proceeds according to the same dialectical laws that we observe throughout nature (and why should the human race claim the unlikely “privilege” of being entirely exempt from objective laws of development?) then the pattern of human history for the first time begins to make sense. It can be explained. It can even — within certain limits — be predicted, although predictions of complex phenomena are not as straightforward as ones involving simple linear processes. This applies just as much to predicting an earthquake or the weather as it does to anticipating the movement of society. No one can say for certain when the city of Los Angeles will fall victim to a catastrophic earthquake, but one can predict with absolute certainty that such a thing will happen.

Despite the most strenuous efforts to deny the validity of dialectics, the latter always takes its revenge on its most hardened detractors. The conservative geological community has been compelled to accept continental drift, the birth and death of continents, which they once laughed out of court. Biologists have been compelled to accept that the old idea of evolution as a gradual, uninterrupted process of adaptation is one-sided and false; that evolution takes place through catastrophic qualitative leaps, in which death (extinction) becomes the precondition for birth (new species).

At every turn, the wealth of material furnished by the natural sciences compel scientists to adopt dialectical conclusions. However, they soon become uncomfortably aware of the potentially “subversive” implications of such ideas. It is at this point that they hasten to resort to all kinds of embarrassed disclaimers and subterfuges in order to cover up their tracks. The usual get-out is to protest ignorance concerning philosophy in general. Like Oscar Wilde’s “love that dare not speak its name,” these authors who wax eloquent about everything under the sun, find themselves utterly unable to pronounce the words dialectical materialism. At best, they insist, in effect, that dialectical materialism is valid for their own narrow specialty but has no application to the broader field of science or (perish the thought!) to society at large.

It is surprising that even those proponents of the theory of chaos who come quite close to a dialectical position display a complete lack of knowledge about Marxism. Thus, Ian Stewart and Tim Poston could write in *Analog* (November 1981) the following lines:

So the “inexorable laws of physics” on which — for instance — Marx tried to model his laws of history, were never really there. If Newton could not predict the behavior of three balls, could Marx predict that of three people? Any regularity in the behavior of large assemblies of particles or people must be statistical, and that has quite a different philosophical taste.³⁹

This is completely off the mark. Marx did not base his model of history on the laws of physics at all. The laws of social development must be derived from a painstaking study of society itself. Marx and Engels devoted the whole of their lives to such a study, based upon a colossal amount of carefully collected empirical data, as even the most superficial examination of the three volumes of *Capital* alone will reveal. Incidentally, both Marx and Engels were highly critical of mechanical determinism in general and Newton in particular. The attempt to establish some parallel between Marx’s method and that of Newton and Laplace is without the slightest foundation.

The closer chaos and complexity theory moves to an examination of existing society, the greater is the potential for arriving at an understanding of the contradictions of capitalism:

But in the United States, the ideal is maximum individual freedom — or, as (Brian) Arthur puts it, “letting everybody be their own John Wayne and run around with guns.” However much that ideal is compromised in practice, it still holds mythic power.

But increasing returns cut to the heart of that myth. If small chance events can lock you into any of several possible outcomes, then the outcome that’s actually selected may not be the best. And that means that maximum individual freedom — and the free market — might not produce the best of all possible worlds. So by advocating increasing returns, Arthur was innocently treading into a minefield. (Brian Arthur is an economist and one of the theoreticians of complexity.)⁴⁰

Stephen Jay Gould, who has made an important contribution to current evolutionary theory, is one of the few Western scientists who has openly recognized the parallels between his theory of “punctuated equilibria” and dialectical materialism. In his book, *The Panda’s Thumb*, he says the following:

If gradualism is more a product of Western thought than a fact of nature, then we should consider alternative philosophies of change to enlarge our realm of constraining prejudices. In the Soviet Union, for example, scientists are trained

with a very different philosophy of change — the so-called dialectical laws, reformulated by Engels from Hegel's philosophy. The dialectical laws are explicitly punctuational. They speak, for example, of the 'transformation of quantity into quality.' This may sound like mumbo jumbo, but it suggests that change occurs in large leaps following a slow accumulation of stresses that a system resists until it reaches the breaking point. Heat water and it eventually boils. Oppress the workers more and more and bring on the revolution. Eldredge and I were fascinated to learn that many Russian paleontologists support a model similar to our punctuated equilibria.

Paleontology and anthropology are, after all, only separated by a very thin wall from the historical and social sciences, which have potentially dangerous political implications for the defenders of the status quo. As Engels pointed out, the nearer one gets to the social sciences, the less objective and the more reactionary they become. It is therefore encouraging that Stephen Gould has come quite close to a dialectical point of view, despite his obvious caution:

Nonetheless, I will confess to a personal belief that a punctuational view may prove to map tempos of biological and geologic change more accurately and more often than any of its competitors — if only because complex systems in a steady state are both common and highly resistant to change.⁴¹

In the last century, Marx ironically pointed out that most of the natural scientists were "shamefaced materialists." In the last half of the 20th century, we have a still greater paradox. Scientists who have never read a word of Marx or Hegel, have independently arrived at many of the ideas of dialectical materialism. We are firmly convinced that the future development of science will confirm the importance of the dialectical method, and that those who pioneered it will finally obtain the recognition which has been denied them.

Stalinist Caricature

A serious obstacle in the path of many who approached the ideas of Marxism in the past was the caricature presented by Stalinism. This played a contradictory role. On the one hand, the tremendous successes of the nationalized planned economy in the Soviet Union powerfully attracted many workers and intellectuals in the West. Prominent scientists such as the celebrated biologist J. B. S. Haldane in Britain were drawn to Marxism, and began to apply it to their own fields with promising results. A large number of works appeared which attempted to explain the latest discoveries of science in a comprehensible language. The results were uneven, but this literature was infinitely preferable to the mystifying stuff produced for popular consumption today.

There is no doubt that the unprecedented advances of culture, education and science in Russia served as a point of reference not just for the international labor movement, but for the best of the intellectuals and scientists in the West. These achievements showed the potential of a nationalized planned economy, despite all the monstrous bureaucratic distortions which ultimately undermined it. They stand in stark contrast to the present situation. The fall of the Soviet Union, and the attempt to move in the direction of a “market economy” has produced a frightful collapse of the productive forces and culture. Overnight, a colossal ideological counter-offensive has been launched on a world scale against the idea of a planned economy, Marxism and socialism in general. The enemies of socialism have taken advantage of the crimes of Stalinism to attempt to blacken the name of Marxism. They aim to convince people that revolution does not pay and that, consequently, it is better to put up with the rule of the big banks and monopolies, accept mass unemployment and falling living standards, because, they say there is “no alternative.”

In reality, what failed in Russia was not socialism, but a bureaucratic caricature of socialism. A totalitarian and bureaucratic system is incompatible with a regime of nationalized planned economy which, as Leon Trotsky explained in 1936, needs democracy as the human body needs oxygen. Without the active and conscious participation of the population at all levels, without complete freedom of criticism, discussion and debate, it would inevitably lead to a nightmare of bureaucracy, corruption, red tape, bungling and mismanagement, which would undermine the basis of the planned economy in the end. This is precisely what happened in the former Soviet Union, as predicted by Marxists decades ago.

The totalitarian regime of Stalinism, with its inevitable companions, corruption, conformism and toadyism, had its most negative effects in the fields of science and the arts. Despite the enormous impulse given to education and culture by the October revolution and the nationalized planned economy that issued from it, the free development of science was held back by the suffocating bureaucratic regime. More than any other section of society, science and the arts need to develop in an atmosphere of intellectual freedom, freedom to think, to speak, to explore, to make mistakes. In the absence of such conditions, creative thought will wither and die. Thus the USSR, with more scientists than America and Japan together (and they were good scientists), was unable to get the same results as in the West, and gradually fell behind in a whole series of fields.

One of the things which created all kinds of misconceptions about Marxism was the way that it was presented by the Stalinists. The ruling elite in Russia could not tolerate freedom of thought and criticism in any sphere. In the hands of the bureaucracy, Marxist philosophy (“diamat” as they called it) was twisted into a sterile dogma, or a variety of sophism used to justify all the twists and turns of the leadership. According to Lefebvre, at one point things got so bad that the Soviet army high command insisted that lessons on formal logic be put back on the curriculum of military academies because of the shameful confusion caused by the teachers of so-called “diamat.” At least lessons in logic would teach the cadets the ABCs of reasoning. This little incident is enough to expose the caricature nature of the “Marxism” of the Stalinists.

Under Stalin, scientists were forced to accept without question this rigid and lifeless caricature, as well as a number of false theories with no scientific basis which happened to suit the bureaucracy, such as Lysenko’s “theory” of genetics. This discredited the idea of dialectical materialism in the scientific community to a certain extent, and prevented a fruitful and creative application of the method of dialectics to different fields of science, which would have made possible serious advances both in the sciences themselves and in the further elaboration of the philosophical ideas which Marx and Engels explained in outline, but left to future generations to develop and fill out in detail.

It is a condemnation of the Stalinist regime that, for more than six decades, with all the resources of the Soviet state at its disposal, the bureaucracy was unable to introduce a single original idea into the theoretical arsenal of Marxism. In spite of the tremendous advantages of the nationalized planned economy, which created a powerful industry and technology. They proved incapable of adding anything new to the discoveries of Karl Marx, working alone in the library of the British Museum.

Despite everything, the benefits of a planned economy permitted outstanding progress in many fields, a fact which the present avalanche of propaganda would like to conceal. Moreover, where scientists did apply the dialectical method to different fields, interesting results were obtained. This is shown precisely by chaos theory, one area in which Soviet scientists, undoubtedly influenced by dialectical materialism, were in advance of the West by at least two decades. It is not generally realized that the original research into chaos theory was done in the Soviet Union, and this gave an impulse to those Western scientists who were independently coming to the same conclusions,

and whose ideas in turn stimulated the further development of Soviet research into chaos, as Gleick admits:

The blossoming of chaos in the United States and Europe has inspired a huge body of parallel work in the Soviet Union; on the other hand, it also inspired considerable bewilderment, because much of the new science was not so new in Moscow. Soviet mathematicians and physicists had strong tradition in chaos research, dating back to the work of A. N. Kolmogorov in the fifties. Furthermore, they had a tradition of working together that had survived the divergence of mathematics and physics elsewhere.⁴²

19. ALIENATION AND THE FUTURE OF HUMANITY

Capitalism in a Blind Alley

In the period from 1948 to 1973-4, we witnessed a fireworks display of industrial and technological innovation the like of which has never been seen. Yet the very successes of the capitalist system are now turning into their opposite. At this time of writing, there are officially 22 million unemployed in the advanced capitalist economies of the OECD alone, even without considering the hundreds of millions of unemployed and under-employed in Africa, Asia and Latin America. Moreover, this is not the temporary cyclical unemployment of the past. It is a chronic ulcer gnawing at the bowels of society. Like some dreadful epidemic, it strikes down even sections of society which believed themselves safe in the past.

Despite all the advances of science and technology, society finds itself at the mercy of forces it cannot control. On the eve of the 21st century, people look to the future with growing anxiety. In place of the old certainty there is uncertainty. The general malaise affects first and foremost the ruling class and its strategists, who are increasingly aware that their system is in serious difficulties. The crisis of the system finds its reflection in a crisis of ideology, reflected in the political parties, official churches, morality, science and even what passes nowadays for philosophy.

Private ownership and the nation state are the two strait-jackets which hamper and restrict the development of society. From an objective point of view, the conditions for world socialism have existed for decades. However, the decisive factor which permitted capitalism partially to overcome its fundamental contradictions was the development of world trade. After 1945 the domination of the world by the United States, dictated by the need to stave off revolution in Europe and Japan and contain the Soviet Bloc, gave them the

opportunity, through the Bretton-Woods agreement and GATT, to compel the other capitalist powers to lower tariffs and remove other obstacles to the free flow of trade.

This was in complete contrast with the economic chaos of the inter-war period when the intensification of national rivalries expressed itself through competitive devaluation and trade wars which led to the strangling of the productive forces within the narrow confines of private ownership and the nation state. As a consequence of this, the period between the Wars was one of crisis, revolutions and counter-revolutions, culminating in the new imperialist slaughter of 1939-45.

In the post-war period, capitalism partially succeeded in overcoming the fundamental crisis of their system through the integration of world trade, creating a largely unified world market. This provided the basic premise for the massive upswing of the economy in the period of 1948-73, which in turn led to increased living standards, at least for a sizable section of the population of the advanced capitalist countries. Thus, a dying man can, at times, experience a sudden access of energy, which appears to presage a complete recovery, but in reality is only the prelude to a new and fatal relapse.

Periods such as this are not only possible, but inevitable, even in an epoch of capitalist decline, if the existing social order is not overthrown. However, the massive fireworks display of economic growth, amounting to many trillions of dollars over a period of four decades, has in no way changed the nature of capitalism or obliterated the contradictions within it. The long period of economic upswing from 1948 to 1973 is over. Full employment, rising living standards and the welfare state are things of the past. In place of growth we now face economic stagnation, recession and a crisis of the productive forces.

The owners of capital are no longer interested in investing in productive activity. The late Akio Morita, who was chairman of Sony Corporation, repeatedly warned in the 1980s of the mortal danger to the capitalist system of the trend away from productive industry towards services. Since 1950, the USA has lost over half its manufacturing jobs, while three quarters of all jobs are oriented to the service sector. A similar trend exists in Britain, now relegated to a third-rate capitalist power. In an article in the *Director* (February 1988), Morita stated:

What I would like to suggest is that this trend, far from being the matured progression of a maturing economy and something to be encouraged, is destructive. For in the long run an economy that has lost its manufacturing base has lost its vital

center. A service-based economy has no engine to drive it. Thus, complacency about moving from manufacturing to a haven of hi-tech services, where workers sit at computers and exchange information all day, is entirely misplaced.

This is because it is only manufacturing that creates something new, which takes raw materials and fashions them into products that are of more value than the raw materials they are made from. It would seem obvious that the service elements of an economy are subsidiary and dependent upon manufacturing.

Instead of creating jobs and increasing the wealth of society, the big monopolies are dedicating huge resources to speculating in the money markets, organizing predatory takeovers, and other kinds of parasitic activity. Morita pointed out that “Businessmen have become fascinated with the foreign exchange game. They have discovered it can bring quick returns without the need to invest in a productive enterprise. Even some industrial concerns have gone over to the FX Empire. The people who spend their lives hunched over a monitor displaying the latest exchange transactions live in a world all their own. They have no allegiances. They do not make any products. They do not create any new ideas. They trade US \$200 billion each day in London, New York and Tokyo. That is a lot of poker chips, significantly more than the value of the actual goods bought and sold in a day. *That is a lot of water to be sloshing around in the engine room,*” Morita wrote.

Morita compared the situation of world capitalism to playing poker on a sinking ship, and concluded:

“It is a heady game, full of excitement, but wins and losses at the poker table don’t obscure the frightening fact that the ship is sinking and no one realizes it.”

Since Morita wrote these lines, the situation has got worse. The gigantic world market in “derivatives” has now reached the staggering total of \$25 trillion and is completely out of control. This amounts to gambling on a colossal scale. It makes the South Sea Bubble look like a mere trifle. This shows the fundamental unsoundness of world capitalism, which could end up in a new 1929-style financial crash.

Contradictions Remain

In 1848, Marx and Engels predicted that capitalism would develop as a world system. This has been borne out in almost laboratory fashion in the 20th century. The crushing domination of the world market is the most important fact of the epoch. We have a world economy, world politics, world diplomacy, world culture, world wars — there have been two of those in the past hundred

years, and the second came close to extinguishing the light of human civilization. Yet the globalization of the economy does not mean a lessening of the problems, but, on the contrary, an enormous intensification of the contradictions.

In the last decade of the 20th century, despite all the wonders of modern science, two thirds of humanity live on the border line of barbarism. Common diseases such as diarrhea and measles kill seven million children a year. Yet this can be prevented by a cheap and simple vaccination. 500,000 women die each year from complications during pregnancy, and perhaps another 200,000 die from abortions. The ex-colonial countries spent only 4% of their GDP on health — an average of \$41 a head, compare with \$1900 in the advanced capitalist countries.

According to United Nations reports, more than six billion people will inhabit the earth by the year 2000. About half of them will be under the age of 20. Yet most suffer from unemployment, lack of basic education and health care, overcrowding and bad living conditions. An estimated 100 million children aged 6 to 11 are not in school. Two thirds are girls. Incidentally, even in the USA, UNICEF estimates that 20% of children live below the national poverty line. However, the situation in Third World countries has reached a horrific level. As many as a 100 million children live on the streets. In Brazil, this problem is being “solved” by a campaign by the police and murder squads to exterminate children for the crime of being poor. Similar atrocities are being carried out against homeless people in Colombia. Not long ago it was discovered that a large number of men, women and children living on the street had been murdered and their bodies sold to the University of Bogota for dissection by medical students. Such stories fill all civilized people with horror. But it is only the most extreme expression of the morality of a society that treats human beings as mere commodities.

One million children have been killed, four million seriously injured, and five million have become refugees or orphaned as a result of wars in the past decade. In many ex-colonial countries, we have the phenomenon of child labor, often amounting to slavery. The hypocritical protests in the Western media do not prevent the products of this labor from reaching Western markets and increasing the capital of “respectable” Western companies. A typical example was the recently published case of a match factory where children, mostly girls, work a 6-day/60-hour week, with toxic chemicals, for three dollars. A letter to *The Economist* of the September 15, 1993 pointed out that: “Parents do realize the value of

education for the future of their children but often their poverty is so desperate that they cannot do without the wages of their laboring children.”

The main reason for the grinding poverty of the third world is the two-fold looting of the resources through the terms of trade, and the trillion dollars debt owed by the third world to the big western banks. Just to pay the interest on the debt, these countries have to export food needed by their own people and sacrifice the health and education of the people. According to UNICEF, debt repayments have caused incomes in the third world to fall by a quarter, health expenditure by 50% and educational expenditure by 25%. Despite the hypocritical outcry against the destruction of the Amazonian rainforest, Brazilian economists have proved that this is mainly motivated by the need to raised cash for agricultural exports, such as beef, raised on reclaimed land. The financing for such export projects comes from the World Bank and other international financial organizations.

In a very literal sense of the word, humanity stands at the crossroads. On the one hand, all the potential exists to build a paradise in this world. On the other, the elements of barbarism threaten to engulf the entire planet. In addition to everything else, we have the threat to the environment. In their frantic search after profit, the big multinationals are destroying the planet. The tropical rain forest is being devastated at a rate of 29,000 square miles a year. That is an area the size of Scotland. People may speculate on what caused the extinction of the dinosaurs 65 million years ago. But there is no doubt about what is the cause of the present catastrophe — the uncontrolled pursuit of profit and the anarchy of capitalist production.

Even scientists who have nothing in common with socialism have been driven to the conclusion (perfectly logical, if one thinks for a moment) that the only solution is some kind of world planned economy. However, this is not possible on the basis of capitalism. Forty one nations formally endorsed the “*World Conservation Strategy*.” But, in the absence of a world socialist federation, this is mainly an exercise on paper. The interests of the big monopolies decide.

Yet there is no inevitability about this. All the dire predictions about the hopeless plight of humanity, starting with Malthus, have been shown to be false. The potential for human development is limitless. The capacity exists even now to eliminate hunger from the face of the earth. In Western Europe and the United States, agricultural productivity has reached such heights that farmers are paid not to produce food. Good land is taken out of commission. Wheat is thrown into the sea, or mixed with dye to make it inedible. There are mountains

of beef, butter, powdered milk. Spanish olive trees are deliberately uprooted. And there are 450 million people in the world who are malnourished, or actually starving.

Within the foreseeable future, the Pacific Rim countries will probably account for half of world output. The world economy will have come into its own. For centuries, Europeans have regarded themselves as the center of the globe. Objectively speaking, this has no more basis than the idea of Ptolemy that the earth stood at the center of the universe. Already in the 1920s Trotsky predicted that the center of gravity of world history would pass from the Atlantic to the Pacific. The next stage of human history will see the multi-millions masses of Asia realize their full potential, as part of a Socialist World Federation.

The Scourge of Unemployment

Work is our main life's activity. From the earliest age, we prepare for it. Our schooling is geared to it. We spend all our active life involved in it. Work is the basis upon which society rests. Without it, there would be no food, no clothing, no shelter, no schools, no culture, no art and no science. In a very real sense, work is life. To deny a person the right to work is not just to deny him or her the right to a minimum standard of living. It is to deprive a person of human dignity, to cut them off from civilized society, to render their lives futile and meaningless. Unemployment is a crime against humanity. The creation of a kind of under-class in the inner cities of the United States and other countries is a condemnation of modern society.

The following quotations reveal the fears of the most conscious strategists of capital about the tendency towards social disintegration in the West:

The concentration of growing populations of disgruntled and impoverished people in cities dependent upon vulnerable infrastructure is fraught with dangers. Not the least of these is a strong likelihood that the social solidarity that underlies the welfare state will be broken apart in the years to come. The steadily escalating costs of supporting dependent populations will try the patience of the more successful in an economic downturn...But that is the problem for the next century.

The welfare state has made failure pay in evolutionary terms. Underclass women give birth to 60% more children than middle class women — black or white. But even this statistic underestimates the impact on the population. Underclass women not only have more children, they also give birth at a younger age, leading to a geometric rise in the underclass population over time.

Rees-Mogg, who comforts himself with the delusion that “*Marxism is dead*,” gives voice to the politics of open reaction, which vividly recalls the pronouncements of Victorian Malthusians a hundred years ago:

They (the poor) are abetted in the wasting of their lives by the perverse incentives of entitlement programs that impose effective tax rates of 100% or more on those who shun welfare to take a job. In many cases, the total value of food stamps, rent subsidies, welfare payments, income supplements, and free medical care and other services exceeds the after-tax income that can be earned in unskilled work. And welfare entitlements, by definition, can be realized with little or no daily effort. You don’t have to rise in the morning and rush through a crowd of commuters to secure your livelihood...Lax law enforcement also makes illiteracy, idleness, and illegitimacy more attractive. Children who can make one hundred dollars per hour as thieves or drug dealers are less likely to be impressed with the rigors of learning to read or keeping a minimum-wage job that may pay off in a better life only in the future.⁴³

On the other side of the Atlantic, the same feeling of foreboding is spreading among the strategists of capital. The well-known American author and economist, John Kenneth Galbraith, unlike Rees-Mogg, is a liberal in politics, but has come to similar conclusions. In his latest book *The Culture of Contentment*, he issues a stark warning of explosive social conflict arising out of class divisions in American society:

Yet the possibility of an underclass revolt, deeply disturbing to contentment, exists and grows stronger. There have been outbreaks in the past, notably the major inner-city riots in the latter 1960s, and there are several factors that might lead to a repetition.

In particular, it has been made clear, tranquility has depended on the comparison with previous discomfort. With time, that comparison fades, and also with time the past promise of escape from relative privation — of upward movement — diminishes. This especially could be the consequence of a slowing or shrinking economy and even more of a prolonged recession or depression. The successive waves of workers who served the Detroit auto factories and body shops — the refugees from the adjacent farmlands of Michigan and Ontario and later the poor whites from Appalachia — went up and on. Many of those who came from the South to replace them are now stalled in endemic unemployment. No one should be surprised if this should, someday, breed a violent reaction. It has always been one of the high tenets of comfort that the uncomfortable accept peacefully, even gladly, their fate. Such a belief today may be suddenly and surprisingly disproved.⁴⁴

Alienation

The world is not a collection of isolated individuals; all are somehow connected one with another. (Aristotle)

No man is an Iland, intire of itselfe; every man is a peece of the Continent, a part of the maine; if a Clod bee washed away by the sea, Europe is the lesse, as well as if a Promontorie were, as well as if a Mannor of thy friends or thine own were; any man's death diminishes me, because I am involved in Mankind; and therefore never send to know for whom the bell tolls; it tolls for thee. (John Donne, *Devotions upon Emergent Occasions*, no. xvii)

Human beings became human by separating themselves from their purely animal, that is to say, unconscious, nature. Even the most complex animals cannot match the accomplishments of humankind, which enable it to survive and prosper in the most varied conditions and climates, under the sea, in the skies, and even in space. Human beings have so far raised themselves above their “*natural*,” that is zoological state, that they have mastered their environment to an unparalleled degree. Yet, paradoxically, humans are still controlled by blind forces beyond their control. The so-called “*market economy*” is based upon the premise that people do not control their lives and destinies, but are puppets in the hands of invisible forces, which, like the capricious and insatiable gods of old, rule everything with neither rhyme nor reason. These gods have their high priests, who dedicate their lives to their service. They inhabit the banks and stock exchanges, with their elaborate rituals, and make fat profits out of it. But when the gods get angry, the priests panic, like a herd of frightened beasts, and just as unconscious.

The ancient Romans described a slave as “*a tool with a voice*” (*instrumentum vocale*). Nowadays, many workers might feel that this description could equally apply to them. We are supposed to live in a post-modern, post-industrial, post-Fordist world. But, as far as the conditions of working people are concerned, what has changed? Everywhere, the gains of the past are under attack. In the West living standards, for the majority of people, are being squeezed. The welfare state is being undermined, and full employment is a thing of the past.

In all countries, society is afflicted with a deep sense of malaise. This starts on the top and percolates down to every level. The feeling of insecurity bred by permanent mass unemployment has spread to sections of the workforce who previously believed themselves immune — teachers, doctors, nurses, civil servants, factory managers — nobody is safe. The savings of the middle class, the value of their houses, are likewise threatened by the uncontrolled movements of the money markets and the stock exchange. The lives of billions of human beings are at the mercy of blind forces which operate with a caprice which makes the gods of old seem rational by comparison.

Decades ago, it was confidently predicted that the forward march of science and technology would solve all the problems of humanity. In the future, men and women would no longer be concerned with the class struggle, but with the problem of leisure. These predictions were not at all unreasonable. From a strictly scientific point of view, there is no reason why we should not be in a position to bring about a general reduction in the hours of labor, while simultaneously increasing output and living standards, on the basis of the improved productivity gained from the application of new technology. But the real situation is very different.

Marx explained long ago that, under capitalism, the introduction of machinery, far from reducing the working day, tends to lengthen it. In all the main capitalist countries, we see a merciless pressure on workers to work longer hours for less pay. In its issue of October 24, 1994, *Time* reported a sharp up-turn in the American economy, with booming profits:

But workers complain that for them expansion spells exhaustion. Throughout American industry, companies are using overtime to wring the most out of the US labor force: the factory workweek currently is averaging a near record 42 hours, including 4.6 hours of overtime. 'Americans,' observes Audrey Freedman, a labor economist and member of *Time's* board, 'are the workingest people in the world.' The big-three automakers have pushed this trend to an extreme. Their workers are putting in an average of 10 hours overtime a week and laboring an average of six eight-hour Saturdays a year.

The same article quotes numerous examples of both blue collar and white collar workers from many different industries, who complain of chronic overwork:

"I'm doing the work of three people," says Joseph Kelterborn, 44, who works for the Nynex telephone company in New York City. His department, which installs and maintains fiber-optic networks, has been reduced from 27 people to 20 in recent years, in part by combining what were once three separate positions — switchman, powerman and tester — into his job of carrier switchman. As a result, says Kelterborn, he often works up to four extra hours a day and one weekend in three. "By the time I get home," he complains, "all I have time for is a shower, dinner and a little sleep; then it's time to turn around and do it all over again."

As Marx pointed out, increased use of machinery under capitalism means longer hours of toil for those who still have a job. Since the recovery from the previous recession began in March 1991, the US economy has created almost six million new jobs, but in such a way that leaves it two million jobs short. If US

companies had hired workers at the same rate as in past expansions, the increase in jobs would have been eight million or more.

The *Time* article adds:

There is much evidence, in fact, that the US is developing something of a two-tiered society. While corporate profits and executive salaries are rising rapidly, real wages (that is, discounted for inflation) are not growing at all. Indeed, the government has reported that last year real median household income in the US fell by \$312, while a million more people slipped into poverty; those officially defined as poor were 15.1% of the US population vs. 14.8% in 1992. Those were astonishing developments for the fourth year of a business recovery that is steadily gaining strength.

In the *Communist Manifesto*, Marx and Engels pointed out that “owing to the extensive use of machinery and to division of labor, the work of the proletarians has lost all individual character, and, consequently, all charm for the workman. He becomes an appendage of the machine, and it is only the most simple, most monotonous, and most easily acquired knack, that is required of him. Hence, the cost of production of a workman is restricted, almost entirely, to the means of subsistence that he requires for his maintenance, and for the propagation of his race. But the price of a commodity, and therefore also of labor, is equal to its cost of production. In proportion, therefore, as the repulsiveness of the work increases, the wage decreases. Nay more, in proportion as the use of machinery and division of labor increases, in the same proportion the burden of toil also increases, whether by prolongation of the working hours, by increase of the work exacted in a given time or by increased speed of the machinery, etc.”⁴⁵

In one of Charlie Chaplin’s most famous films, *Modern Times*, we have a graphic picture of life on the assembly line of a big plant in the 1930s. The mindless drudgery of an endless repetition of the same monotonous tasks indeed changes a human being into an appendage of the machine, a “tool with a voice.” Despite all the fancy talk about “participation,” conditions in most factories remain much the same. Indeed, the pressure on workers has been steadily stepped up in recent years. The little things which made life a bit more bearable are being ruthlessly whittled away. In Britain, where the strength of the unions achieved notable advances in the past, the lunch-hour has largely passed into history. Chancellor Kohl informs the German workers that they must begin to work weekends. It is the same picture everywhere.

Instead of new technology improving the lot of the worker in industry, it has been used to worsen the conditions of the white-collar worker. In most banks, hospitals and large offices, the position of the employees is more and more similar to that which exists in big factories. The same insecurity, the same

relentless pressure on the nervous system, the same stress, leading to medical problems, depression, the break-up of marriages.

In recent years scientists have returned to the idea of a “*man-machine*,” in relation to the field of robotics and the question of artificial intelligence. It has even penetrated the popular imagination, as witnessed by a spate of films of the *Terminator* type, where human beings are pitted against ingeniously-constructed automata. This latter phenomenon tells us quite a lot about the psychology of the present period, characterized by the general dehumanizing of society, mixed with a sensation that human beings are not in charge of their own destiny, and fear of uncontrollable forces that dominate people’s lives. By contrast, the attempt to create artificial intelligence represents a further advance of the science of robotics, which, in a genuinely rational society, opens up a truly marvelous vista of human advancement.

The substitution of human toil by advanced machinery is the key to the greatest cultural revolution in history, on the basis of a generalized reduction in the hours of work. Nevertheless, there can be no question of ever exactly reproducing human thought in a machine, although specific operations can be done more efficiently by them. This is not for any mystical reasons, or because of an “*immortal soul*” which allegedly makes us a unique product of Creation, but because of the nature of thought itself, which cannot be separated from all the other bodily activities of human beings, beginning with labor.

Marx and Alienation

Even for those fortunate enough to have a job, nine times out of ten, work is meaningless drudgery. The hours of labor are not thought of as part of one’s life. They are nothing to do with you as a human being. The product of your labor belongs to someone else, for whom you are just a “factor of production.” Life begins the moment you step outside the workplace, and ceases the moment you re-enter it. This phenomenon was well explained by Marx in his *Economic and Philosophic Manuscripts of 1844*:

What, then, constitutes the alienation of labor?

First, the fact that labor is external to the worker, i.e., it does not belong to his intrinsic nature; that in his work, therefore, he does not affirm himself but denies himself, does not feel content but unhappy, does not develop freely his physical and mental energy but mortifies his body and ruins his mind. The worker therefore only feels himself outside his work, and in his work feels outside himself. He feels at home when he is not working, and when he is working he does not feel at home. His

labor is therefore not voluntary, but coerced; it is forced labor. It is merely a means to satisfy needs external to it. Its alien character emerges clearly in the fact that as soon as no physical or other compulsion exists, labor is shunned like the plague.

External labor, labor in which man alienates himself, is a labor of self-sacrifice, of mortification. Lastly, the external character of labor for the worker appears in the fact that it is not his own, but someone else's, that it does not belong to him, that in it he belongs, not to himself, but to another. Just as in religion the spontaneous activity of the human imagination, of the human brain and the human heart, operates on the individual independently of him — that is, operates as an alien, divine or diabolical activity — so is the worker's activity not his spontaneous activity. It belong to another; it is the loss of his self.⁴⁶

Thus, for the great majority, life is mainly taken up in an activity which has very little meaning for the individual; at best, it is tolerable; at worse, a living torment. Even those who take a job like teaching children or nursing sick people are finding that the satisfaction they get is being taken away, as the laws of the market-place force their way into the classroom and the hospital ward.

The feeling that society has reached an impasse is not confined to the “lower orders.” In the ruling class also there is an increasing feeling of malaise and pessimism with regard to the future. One looks in vain for the great ideas of the past, the confidence, the optimism. The constant bragging about the supposed wonders of the “free market economy” have an increasingly empty ring about them, as people begin to take stock of the real situation — the millions of unemployed, the attacks on living standards, the fabulous fortunes made through speculation, greed, and corruption.

It is ironical that the defenders of the existing order accuse Marxism of “materialism,” when the bourgeois themselves practice the most gross and vulgar kind of materialism, in the dictionary, not the philosophical, sense of the word. The mindless pursuit of wealth, the elevation of greed as the dominant principle of all things, is at the center of their whole culture. It is their real religion. In the past, they took care to conceal this from view as much as possible, hiding behind a screen of hypocritical moralizing about duty, patriotism, honest toil, and all the rest. Now it is all out in the open. In every country, we see an unprecedented epidemic of corruption, swindling, lying, cheating, theft — not the petty theft of ordinary criminals, but looting on a massive scale, perpetrated by businessmen, politicians, police-chiefs and judges. And why not? Is it not our duty to get rich?

The creed of monetarism elevates egotism and greed to a principle. Grab as much as you can, however you can, and may the devil take the hindmost! This is the distilled essence of capitalism. The law of the jungle, translated into the

language of voodoo economics. At least it has the merit of simplicity. It says bluntly and clearly what the capitalist system is all about.

Yet what an empty philosophy! What a miserable conception of human life! Though they do not know it, the lords of the planet are themselves mere slaves, blind servants of forces they do not control. They have no more real command of the system than ants in an anthill. The point is that they are quite satisfied with this state of affairs, which gives them position, power and wealth. And they grimly resist all attempts to carry out a radical change in society.

If there is a single thread running through human history, it is the struggle of men and women to gain control over their lives, to become free in the true sense of the word. All the advances of science and technique, all that humans have learned about nature and ourselves, means that the potential now exists to gain full mastery over the conditions in which we live. Yet, in the last decade of the 20th century, the world seems to be in the grip of a strange madness. Human beings feel even less in control of their destinies than before. The economy, the environment, the air we breathe, the water we drink, the food we eat — all seems to be under threat. Gone is the old sense of security. Gone is the feeling that history represents an uninterrupted march towards something better than the present.

Under these circumstances, sections of society look for a way out in such things as drugs and alcohol. When society is no longer rational, men and women turn to the irrational for solace. Religion is, as Marx said, an opium, and its effects are no less harmful than other drugs. We have seen how religious and mystical ideas have penetrated even the world of science. This is a reflection of the nature of the period through which we are passing.

Morality

Seek to strengthen your moral commitments and religious faith. Reread the Ten Commandments and the Book of Ecclesiastes. A Bible is not a bad teacher of history and a guide to survival in hard times (Rees-Mogg).

Whoever does not care to return to Moses, Christ or Mohammed. Whoever is not satisfied with eclectic hodgepodes must acknowledge that morality is a product of social development; that there is nothing immutable about it; that it serves social interests; that these interests are contradictory; that morality more than any other form of ideology has a class character . . . (Trotsky).

“*Marxism denies morality!*” How often have we heard expressions of this type, which merely reveal ignorance of the ABCs of Marxism. True, Marxism denies

the existence of a supra-historical morality. But it does not require much effort to show that the moral codes which have regulated human conduct have varied substantially from one historical period to another. At one time, it was not considered immoral to eat prisoners of war. Later on, cannibalism was regarded with abhorrence, but prisoners of war could be turned into slaves. Even the great Aristotle was prepared to justify slavery, on the grounds that slaves did not possess souls, and therefore were not fully human (the same argument was used in relation to women). Still later, it was considered morally wrong for one person to own another as a piece of property, but perfectly acceptable for feudal lords to have serfs who were chained to the land and entirely subject to the master, to the point of giving up his bride to the lord on her wedding night.

Nowadays, all these things are regarded as barbarous and immoral, but the institution of wage-labor, where a human being sells himself piecemeal to an employer, who uses his labor-power as he pleases, is never called into question. This is, after all, free labor. Unlike the serf and the slave, the worker and employer arrive at an agreement of their own free will. Nobody obliges the worker to work for a particular boss. If he does not like it, he may leave and seek employment elsewhere. Moreover, in a free market economy, the law is the same for everyone. The French writer Anatole France wrote about the “*majestic egalitarianism of the law, which forbids rich and poor alike to sleep under bridges, to beg in the streets, and to steal bread.*”

In modern society, in place of the old open forms of exploitation, we have disguised, hypocritical exploitation, in which the real relation between men and women is translated into a relation between things — little bits of paper which give their owners the power of life and death; which can make what is ugly beautiful; what is weak, strong; what is stupid, intelligent; what is old, young.

Trotsky wrote that money relations have sunk so deep into people’s minds that we refer to a man as being “worth” so many million dollars. It is a measure of the degree of alienation that exists in present-day society that such expressions are taken for granted. Nor is anyone surprised when, during, a monetary crisis, the television talks about the currency as if it were a person recovering from an illness (“*The pound / dollar / Deutschmark was a little stronger today...*”). Human beings are regarded as things, while objects, especially money, are regarded with superstitious awe, recalling the religious attitudes of savages to their totems and fetishes. The reason for this fetishism of commodities was explained by Marx in the first volume of *Capital*.

The search for an absolute morality proves to be completely futile. Here again, the immutable laws of logic can offer us no help. Formal logic basis itself on a fixed antithesis between truth and falsehood. An idea is either right or wrong. Yet truth, as the German poet Lessing pointed out, is not like a stamped coin that is issued ready from the mint and can be used under all circumstances. What is true at one time and under one set of circumstances becomes false in another. The same is the case with concepts like “good” and “evil.” What is “good” and praiseworthy in one society, is abhorrent in another. Moreover, even within a given society, the concept of what is good and bad frequently changes, according to circumstances, and to the interests of a particular class.

If we exclude incest, which appears to have been taboo in virtually all societies, there are very few moral injunctions which can be shown to have been eternal and absolute. “Thou shalt not steal” does not make much sense in a society not based on private property. “Thou shalt not commit adultery” only has meaning for a male-dominated society, where men wished to be sure that private property was handed down to their own sons. “*Thou shalt not kill*” has always been surrounded by so many qualifications that it immediately becomes transformed into something quite different, or even its opposite; for example, thou shalt not kill, except in self-defense; or, thou shalt not kill, unless it is somebody from another tribe/nation /religion, and so on.

In every war, the armies of the nation are blessed by the priests as they go out to slaughter the armies of other nations. The absolute moral injunction not to kill suddenly turns out to be relative to other considerations, which, on closer examination, are found to be related to the economic, territorial, political, or strategic interests of the states involved in the fighting. The hypocrisy of all this was well expressed in a little verse by the great Scottish poet Robert Burns On Thanksgiving For a National Victory:

*Ye hypocrites! are these your pranks?
To murder men, and give God thanks?
Desist for shame! Proceed no further:
God won't accept your thanks for Murther.*

War is a fact of life (and death). There have been many wars throughout human history. The fact may be deplored, but not denied. Moreover, all the most important issues between nations have ultimately been settled by war. Pacifism has never been a fashionable doctrine with governments, except as the small-change of diplomacy, the exclusive aim of which is to deceive everyone concerning the real intentions of the government it represents. Lying is the

stock-in-trade of diplomats. It is what they are paid for. "*Thou shalt not bear false witness*" simply does not come into it. An army commander who did not do everything in his power to deceive the enemy about his intentions would be considered a fool or worse. Here, however, a lie becomes something praiseworthy — a military ruse. A general who told the truth about his plans to the enemy would be shot as a traitor. A worker who revealed details of a strike to the employer would be regarded in the same way by his or her workmates.

From these few examples, it is clear that morality is not a supra-historical abstraction, but a something which has evolved historically, and undergone considerable changes. In the Middle Ages, the Roman Catholic Church condemned usury as a deadly sin. Nowadays, the Vatican has a bank of its own, and raises very large sums of money by lending at interest. In other words, morality has a class basis. It reflects the values, interests and outlook of the dominant social class. Of course, it cannot succeed in maintaining the necessary degree of social cohesion if it is not accepted by the great majority of citizens. Hence, it must appear to consist of absolute and unquestionable truths, the violation of which must bring the whole social edifice crashing down.

There are few sights more repulsive than the sight of well-to-do ladies and gentlemen lecturing the public on the need for morality, religion, family planning and thrift. The same individuals whose selfish greed is manifested every day in huge salary increases for boardroom directors lecture workers on the need for sacrifice. The same speculators, who do not hesitate to plunge the currency of their own country into chaos in order to increase their already swollen bank balances, lecture us on the need for patriotic values. The same banks, multinationals and governments that have been responsible for the merciless squeezing of millions in Africa, Asia and Latin America throw up their hands in horror whenever the workers and peasants take up arms to fight for their rights. They lecture the world on the need for peace. But the stocks of murderous weaponry upon which they continue to lavish fabulous sums show that their pacifism is also quite relative. Violence is only a crime when it is resorted to by the poor and oppressed. The whole of history shows that the ruling class will always defend its power and privileges by the most brutal means, if necessary.

Family, Order, Private Property and Religion have always been inscribed on the banners of conservative defenders of the status quo. Yet of these supposedly inviolate institutions, only one, private property, is of real interest to the ruling class. Religion is, as Rees-Mogg bluntly points out, a necessary weapon to keep the poor in order. Most of the upper class do not believe a word

of it, and go to Church, much the same as they go to the opera, in order to show off the latest fashion. Their understanding of theology is as scanty as their appreciation of Wagner's Ring cycle. In their private life, the bourgeois show scant consideration for the "eternal laws of morality." The epidemic of scandals which have rocked the political establishment in Italy, France, Spain, Britain, Belgium, Japan and the United States is just the tip of the iceberg. Yet they prate endlessly on about "*eternal moral truths*" and are surprised when they are greeted with a resounding guffaw.

Does this mean that morality does not exist? Or that Marxists do not have a morality? Far from it. Morality exists, and plays a necessary role in society. Every society has an ethical code, which serves as a powerful bond, to the degree that it is recognized and respected by the great majority. Ultimately, existing morality and the legal code which seeks to put it into practice is backed by the full force of the state, reflecting the interests of the ruling class or caste, although it does so in a disguised way. While the existing socioeconomic order carries society forward, the values, ideas and outlook of the ruling stratum are accepted without question by the great majority. The class basis of morality was explained by Trotsky:

The ruling class forces its end upon society and habituates it into considering all those means which contradict its ends as immoral. That is the chief function of official morality. It pursues the idea of the 'greatest possible happiness' not for the majority but for a small and ever-diminishing minority. Such a regime could not have endured for even a week through force alone. It needs the cement of morality.

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Those few individuals who dare to question it are branded as heretics and persecuted. They are regarded as "*immoral*" people — not because they do not possess a moral standpoint, but because they do not conform to the existing morality. Socrates was declared to be a harmful influence on the Athenian youth, before being made to drink hemlock. The early Christians were accused of all manner of immoral acts by the slave state that persecuted them mercilessly before it decided it would be better to recognize the new faith, in order to corrupt the leaders of the Church. Luther was denounced as an evil man, when he opened up an attack on the corruption of the medieval Church.

The crime of Marxists is to point out that capitalist society has entered into conflict with the needs of social development; that it has become an intolerable obstacle to human progress; that it is shot through with contradictions; that it is economically, politically, culturally and morally bankrupt; and that the further

survival of this sick system puts the future of the planet in grave danger. From the standpoint of those who own and control the wealth of society, these ideas are “*bad*.” From the standpoint of what is needed to find a way out of the impasse, they are correct, necessary, and good.

The long drawn-out crisis of capitalism is having a most negative effect on morality and culture. Everywhere, the symptoms of social disintegration are palpable. The bourgeois family is breaking down, but, in the absence of anything to put in its place, this is leading to a nightmare of poverty and degradation for millions of needy families. The decaying inner cities of the United States and Europe, with their huge pools of unemployment and deprivation, are a spawning-ground for drug abuse, crime, and every kind of nightmare.

In capitalist society, people are regarded as dispensable commodities. Goods which cannot be sold lie idle until they rot. Why should human beings be any different? Only it is not so simple with people. They cannot be allowed to starve to death in large numbers, for fear of the social consequences. So, in the ultimate contradiction of capitalism, the bourgeois is obliged to feed the unemployed, instead of being fed by them. A truly insane situation, where men and women wish to work, to add to the wealth of society, and are prevented from doing so by the “*laws of the market*.”

This is an inhuman society, where people are subordinated to things. Is it any wonder that some of these people behave in an inhuman manner? Every day the tabloid press is full of horror stories about the terrible abuses committed against the weakest, most defenseless sections of the community — women, children, old people. This is an accurate barometer of the moral state of society. The law sometimes punishes these offences, although in general crimes against (big) property are more energetically pursued by the police than crimes against the person. But in any case, the profound social roots of crimes are outside the powers of courts and police. Unemployment breeds crimes of all sorts. But there are other, more subtle factors.

The culture of egotism, greed and indifference to the sufferings of others has flourished, particularly in the last two decades, when it was given the stamp of approval by Thatcher and Reagan, has undoubtedly played a role, though it is not so easy to quantify. This is the real face of capitalism, more accurately of monopoly and finance capital — ruthless, crude, grasping and cruel. This is capitalism in its period of senile decay, attempting to recover the vigor of its youth. It is parasitic capitalism, with a marked preference for the fleshpots of financial and monetary speculation, instead of the production of real wealth. It

prefers “services” to industry. It closes factories like matchboxes, ruthlessly destroying whole communities and industries, and recommends miners and steelworkers to find work in hamburger bars. It is the 20th century equivalent of “*Let them eat cake.*”

Quite apart from the monstrous social and economic consequences of this doctrine, it spreads a deadly moral poison through the fabric of society. People with no prospect of even finding a job are confronted with the spectacle of the “consumer society,” where getting and spending money are presented as the only worthwhile activity in life. The role-models of this society are the pushy parvenus, the get-rich-quick mob, prepared to go to any lengths to “get on.” This is the true face of “free enterprise,” of monetarist reaction — it is the face of an unprincipled adventurer, a crook and a swindler, a shallow ignoramus, a bully in an expensive suit, the personification of greed and selfishness. These are the people who applaud the closure of schools and hospitals, the cutting of pensions and other “unprofitable” items of expenditure, while they make fortunes by lifting a phone, without ever producing anything of use for the benefit of society.

It is often asserted that people “naturally” act according to their interests. This is then interpreted in a narrow way, as personal egotism. Such an interpretation suits the defenders of the present socioeconomic system, in which greed and the pursuit of self-interest are held up as great moral principles, equivalent to the exercise of “personal freedom.” If this had been the case, human society could never have developed. The word “interest” itself comes from the Latin “inter-esse” which means “to take part in.” The whole basis of the intellectual and moral evolution of the child is the movement away from “egotism” and towards a greater sense of the needs and requirements of others. Human society is based on the necessity of social production, co-operation and communication.

It is the impasse of capitalism which threatens to push human culture back to a childish level, in the worst sense of the word — the childishness of senile decay. An atomized, self-centered society without a vision, without a morality, without a philosophy, without a soul, a society “*sans teeth, sans eyes, sans taste, sans everything.*”

Limitless Possibilities

Every social system imagines itself to be the last word in historical development. All previous history was supposed to be only a preparation for this particular mode of production, and all the legal property forms, moral code,

religion and philosophy that accompany it. Yet any system of society only exists to the degree that it shows it is capable of satisfying the needs of the population, and giving people hope for the future. The moment it fails to do this, it enters into an irreversible process of decline, not only economically, but morally, culturally, and in every respect. Such a society is dead, even though its defenders will never admit it.

As the 20th century draws to a close, there is a palpable and all-pervasive feeling of weariness and exhaustion in capitalist society. It is as if a whole way of life has become old and decrepit. This is not just what writers refer to as the “*mal du siècle*.” It is a vague realization that the “*market economy*” has reached its limits. Yet, though a given form of society has outlived itself, this does not mean that the development of humankind is similarly limited. History has not only not ended. It has not even begun. If we envisage history as a calendar in which 1st January represents the origin of the earth and 31st December represents the present day, taking a round figure of 5,000 million years as the age of the earth, each second will represent about 167 years, each minute 10,000 years. The Lower Cambrian would then begin on 18 November. Man would appear at about 11.50 P.M. on 31st December. The whole of recorded human history would fall within the final forty seconds before midnight.

Ilya Prigogine has wisely remarked that “*Scientific understanding of the world around us is just beginning.*” Human civilization, which seems to us to be very old, is actually very young. In fact, real civilization, in the sense of a society where humans consciously control their own lives, and are able to live a truly human existence, as opposed to the animal struggle for survival, has not yet commenced. What is true is that a particular form of society has become old and exhausted. It clings to life, though it has no longer anything to offer. Pessimism about the future, mingled with superstition and unfounded hopes for salvation, are entirely characteristic of such a period.

In 1972, the Club of Rome published a gloomy report entitled *The Limits of Growth* which predicted that the world's supply of fossil fuels would run out in a few decades. This provoked panic, soaring oil prices and a frantic search for alternative sources of energy. More than twenty years later, there is no shortage of oil or gas, and few now bother to look for alternatives. This shortsightedness is a characteristic of capitalism, which is motivated by the search for short-term profits. Everyone knows that sooner or later the supply of fossil fuels will dry up. A long term plan is absolutely necessary to find a cheap, clean alternative.

Nature provides a literally limitless supply of potential energy — the sun, the wind, the sea, and, above all, matter itself, which contains vast quantities of untapped energy. Nuclear fusion (unlike nuclear fission) provides a potential for limitless amounts of cheap, clean energy. But the development of alternative fuels is not in the interests of the big oil monopolies. Here again, private ownership of the means of production acts as a gigantic barrier in the path of human development. The future of the planet comes a poor second to the cause of the enrichment of a few.

The solution to the pressing problems of the world can only be found in a socioeconomic system which is under the conscious control of people. The problem is not that there is an inherent limit to development. The problem is an out-dated and anarchic system of production which squanders lives and resources, destroys the environment, and prevents the potential of science and technology being developed to the full. “*There is no necessary connection between great science and great business opportunities,*” one commentator wrote recently, “*the general theory of relativity has yet to be turned into a money-spinner.*” (*The Economist*, February 25, 1995.)

Yet even at the present time, the possibilities implicit in technology are breathtaking. Technological innovations open the door to a genuine cultural revolution. Interactive television is already a feasible proposition. The possibility of actively participating in the elaboration of television programs has tremendous potential, far more than merely deciding what programs you want to watch. It opens the door to democratic participation in the running of society and the economy in a way that could only have been dreamed of in the past.

The birth of capitalism was characterized by the breakdown of the old parochial relations, and the birth of the nation states. Now the growth of the productive forces, science and technique have made the nation state itself redundant. As Marx predicted, even the biggest nation state is compelled to participate on the world market. The old national one-sidedness has become impossible.

Back to the Future?

Early humans were closely bound to nature. This bond was gradually broken with the development of urban life, and the division between town and country, which has reached monstrous proportions under capitalism. The rupture between human beings and nature has created an unnatural world of

alienation. A further manifestation of this is the complete divorce between mental and manual labor, that unwholesome social apartheid which separates the modern priest-caste of knowledge from the “hewers of wood and drawers of water.” It is not just the alienation of humans from nature. It is the alienation of humanity from itself. To break out of the condition of utter dependence on nature, to rise above the merely animal nature, to acquire consciousness — these are what defines us as human. But this gain is also a loss, and one that is felt ever more keenly as time goes on. The process has gone so far that it has turned into its opposite. As cities become ever vaster, more overcrowded, more polluted, a nightmare is in the making. In the next few decades, Shanghai alone will have more inhabitants than Great Britain, on present trends. Bad housing, crime, drugs, and a general process of dehumanization faces millions of people on the eve of the 21st century.

The suffocating one-sided, artificial nature of this “civilization” becomes increasingly oppressive, even for those who do not suffer the worst conditions. The yearning for a simpler form of life, where men and women could live more natural lives, free from the intolerable pressures of competition and conflict expresses itself in a trend among a layer of young people to “drop out” of society, in an attempt to re-discover a lost paradise. There is a misunderstanding here. In the first place, the life of primitive people was not as idyllic as some imagine. The “*noble savage*” was always a fiction of Romantic writers, with very little in common with reality. Our early ancestors were close to nature, only because they were the slaves of nature.

However, there is another side to this. These “*primitive*” people lived quite happily without rent, interest and profit. Women were not regarded as private property, but occupied a highly respected position in the community. Money was unknown. So was the state, with its monstrous bureaucracy, and special bodies of armed men, soldiers, policemen, prison warders and judges. In primitive tribal communism, there was no state in the sense of an apparatus of coercion, but the elders had the respect of all, and their word was law. Later, the tribal chieftain ruled through the voluntary respect of the community. Coercion was not necessary, because all shared a common interest. This was the basis for a deep social bond of co-operation and unity. No modern ruler could ever know the respect enjoyed by the heads of the old gens, underwritten by a sense of mutual identity and duty, which was “codified” in oral tradition as tribal lore, known to all and universally accepted. This respect must have been similar to the feelings of a child for its parents.

In our supposedly enlightened age, many people, including those who like to think themselves educated, find it unthinkable that men and women could ever have got along without such necessary phenomena as money, policemen, prisons, armies, merchants, tax-collectors, judges and archbishops. And if they did manage to do so, it can only be explained in terms of the fact that, being “primitive,” they had not yet come to realize the blessings that such institutions bestow upon humanity. Even some anthropologists, who do not have this mentality, are not immune from introducing into early human society entirely alien concepts, like prostitution, derived from the “civilized” world where everything is for sale, including people.

Anyone who has seen films of the life of tribes still living in stone-age conditions in the Amazon cannot fail to be impressed by their naturalness and spontaneity, resembling that of children, before it is crushed out of them by the rat-race of life under capitalism. In Matthew’s Gospel, Jesus says: “*Except ye be converted, and become as little children, ye shall not enter into the kingdom of heaven.*” (18:3) In the process of growing up, something important is lost, never to be regained. It is the Fall from innocence, which in the book of *Genesis* is identified with men and women gaining knowledge. Modern society can no more go back to primitive tribal communism than a grown man or woman can become a child again.

It is considered unnatural and unhealthy for an adult to wish to go back to childhood. The word “childish” is used as an insult, a synonym for incongruous ignorance. In any case, it is a futile wish, because it is impossible. But alongside ignorance, the child also displays other qualities — a spontaneous gaiety and naturalness, which is foreign to most adults. The same is true of “primitive” peoples, before the advent of class society, and the one-sided and stultifying division of labor twisted human nature inside out. What modern artist would be capable of producing paintings of such breathtaking immediacy and natural beauty as the work of the cave-artists of Lascaux and Altamira?

It is not a question of going back, but going forward. Not a return to primitive tribal communism, but forward to the future socialist world commonwealth. The negation of the negation brings us back to the starting-point of human development, but only in appearance. The socialism of the future will base itself on all the marvelous discoveries of the past, and place them at the disposal of humanity. To use the language of Hegel, it is a case of the “*universal, filled with the wealth of the particular.*”

*“A man cannot become a child again, or he becomes childish,” writes Marx. “But does he not find joy in the child’s naïveté, and must he himself not strive to reproduce its truth at a higher stage? Does not the true character of each epoch come alive in the nature of its children? Why should not the historic childhood of humanity, its most beautiful unfolding, as a stage never to return, exercise an eternal charm? There are unruly children and precocious children. Many of the old peoples belong in this category. The Greeks were normal children. The charm of their art for us is not in contradiction to the undeveloped stage of society on which it grew. [It] is its result, rather, and is inextricably bound up, rather, with the fact that the unripe social conditions under which it arose, and could alone arise, can never return.”*⁴⁸

Socialism and Aesthetics

In present day society, architecture is the poor relation of the arts. People are accustomed to living in ugly surroundings, in bad housing, in congested cities, surrounded by noise and pollution. At weekends, some of them go to art galleries, where, for a few hours, they can gaze upon paintings hanging on walls — islands of beauty in a sea of monotonous ugliness. Thus beauty is boxed off from life, an unattainable dream, a fiction, as remote from reality as the furthest galaxy from the earth. So remote has art become from life that many people regard it as a useless irrelevance. Hostility towards art, which is seen as the privileged preserve of the middle class, is a further consequence of the extreme division between mental and manual labor. Barbaric conditions breed barbaric attitudes.

It was not always so. In earlier human societies, music, epic poetry and fine speaking were the common property of all men and women. The monopoly of culture by a small minority is the product of class society, which deprives the great majority, not only of property, but of the right to a free development of their minds and personalities. Yet, if we delve a little beneath the surface, we find a great desire to learn, to experience new ideas, to seek broader horizons. The thirst of the masses for culture, deeply repressed under “normal” conditions, comes to the surface in any revolution.

The Russian Revolution of 1917, that allegedly barbarous act, was in fact the starting-point for a great upsurge in culture, poetry, art and music. This cannot be expunged because the blossom was later crushed under the jackboot of Stalinist reaction. In the Spanish revolution of 1931-37, there was a similar artistic renaissance — the poetry of Lorca, Machado, Alberti, and above all, Miguel Hernandez was inspired by the struggle, and in turn was listened to with

rapt attention by audiences of millions who had never before had access to the marvelous world of art and culture.

In a revolution, ordinary men and women begin to see themselves as human beings, capable of controlling their own destinies, not mere *"tools with voices."* With true humanity comes dignity, a sense of self-respect and its necessary companion, respect for others. The waiters put up notices in the restaurants of Barcelona in 1936 saying: *"Just because a man has to work here, it does not mean you have to insult him by offering a tip."* This is the birth of culture — real human culture, which is part of life itself. The same phenomenon, in embryo, can be seen in every strike, where men and women reveal qualities they never dreamed they possessed. Of course, if the movement does not lead to a complete transformation of society, the dead-weight of habit and routine once more predominates. Material conditions determine consciousness. But a socialist society based on a high level of technology and culture would completely transform the outlook of people.

It is often alleged by logicians and mathematicians that the kind of perfect symmetries which they admire possess an intrinsic aesthetic value. Some even go so far as to claim that the most important thing about equations is not whether they tell us anything about reality, but whether they are aesthetically pleasing. Whereas no one will deny that symmetry can be beautiful, there is symmetry and symmetry. The harmonious buildings of classical Athens is considered by many to be one of the high points of the history of architecture. There is certainly a most satisfying symmetry here, and one that recalls the linear relations of Euclidean geometry. The importance of architecture in the Athens of Pericles is a graphic expression of the public-spirited outlook of Athenian democracy (based, of course on the labor of the slaves, who were totally excluded from it). The great buildings of the Acropolis and the Agora were, without exception, public buildings, not private residences. In our own day and age, such splendors are extremely rare. The low priority given to architecture in comparison to other arts is no accident.

In the name of *"utility,"* which is a polite synonym for stinginess, people are forced to live in uniform high-rise concrete boxes, devoid of all artistic merit or human warmth. These monstrosities are designed by architects, inspired by strictly geometrical principles, who nevertheless prefer to live in quaint 15th century cottages in the countryside, far away from the urban nightmares they have helped to create. Yet human beings do not generally like living in boxes.

And nature knows of symmetries very far removed from straight lines and simple circles.

It is the other side of the coin of the mechanized idiocy of the production line, where human beings, in the words of Marx, are treated as mere appendages of the machines. Why, then, should they not live, herded together on big estates in concrete boxes, which are built on similarly sound “*industrial*” principles? The same arid reductionism, the same empty formalism, the same linear approach has characterized architecture most of this century. Here the alienation of late capitalist society expresses itself in the soulless treatment of people’s most basic need, for a clean, attractive, and genuinely human environment to live in. When life itself is stripped of all humanity, when it is made unnatural in a thousand different ways, how can we be surprised if some of the products of our so-called civilization behave in an unnatural and inhuman way?

Here too, we are witnessing a revolt against soulless conformism and rigidity. The high-rise blocks and skyscrapers, aptly described by an English writer as the “*topless towers of idiocy*,” are rapidly falling into disfavor. And no wonder. They are a monument to alienation on a massive scale, a progressive slide into dehumanized conditions of life, which breeds all kinds of monstrosities.

“Why is it,” asked the German physicist Get Eilenberger, “*that the silhouette of a storm-bent leafless tree against an evening sky in winter is perceived as beautiful, but the corresponding silhouette of any multi-purpose university building is not, in spite of all efforts of the architect? The answer seems to me, even if somewhat speculative, to follow from the new insights into dynamical systems. Our feeling for beauty is inspired by the harmonious arrangement of order and disorder as it occurs in natural objects — in clouds, trees, mountain ranges, or snow crystals. The shapes of all these are dynamical processes jelled into physical forms, and particular combinations of order and disorder are typical for them.*”

As James Gleick correctly observes, “*Simple shapes are inhuman. They fail to resonate with the way nature organizes itself or with the way human perception sees the world.*”

49

Long ago Karl Marx pointed to the harmful consequences of the extreme division between town and countryside. It is not a question of “*going back to nature*,” in the utopian sense advocated by certain ecologists, who dream of escaping from the ugliness of the present by retreating into the alleged charms of a non-existent rural paradise in a mythical past. There is no going back. It is not a question of denying technology, but of fighting against the abuse of technology in the cause of private gain, which destroys the environment and creates a hell,

where an earthly paradise ought to exist. That is the central task facing humanity in the last decade of the 20th century.

“Thinkers” and “Doers”

Nec manus, nisi intellectus, sibi permissus, multum valent. (Neither hand nor intellect left each to itself is worth much — Francis Bacon.)

The total divorce between theory and practice in present day society has become harmful in the extreme. The increasingly fantastic character of many of the “theories” put in circulation by certain cosmologists and theoretical physicists is undoubtedly a consequence of this fact. Freed from the constraints of having to furnish any concrete proof of their theories, and relying ever more on complicated equations and arcane interpretations of relativity theory, the results of this wholly speculative thinking are increasingly bizarre.

It is time to re-examine the whole system of education, and the class system of society upon which it rests. It is time to re-consider the validity of dividing humanity into the “thinkers” and “doers,” not from the standpoint of some abstract moral justice, but simply because it has now become a hindrance to the development of culture and society. The future development of humanity cannot be based on the old rigid divisions. New complex technology demands an educated workforce capable of a creative approach to work. That can never be achieved in a society split down the middle by class apartheid. In a very perceptive passage, Margaret Donaldson points out the unsatisfactory situation that exists in universities today:

Consider the engineering departments of our universities. They teach mathematics and physics and so they should. But they do not teach people to make things. You can emerge as a graduate in mechanical engineering without ever having used a lathe or a milling-machine. These things are considered suitable only for the technicians. And for most of them, on the other hand, mathematics and physics beyond an elementary level are quite simply out of reach.

The English philosopher and educationalist Alfred North Whitehead was deeply concerned at this situation, and, in his article *Technical Education and its Relation to Science and Literature*, wrote that “in teaching you come to grief as soon as you forget that your pupils have bodies,” and added: “It is a moot point whether the human hand created the human brain, or the brain created the hand. Certainly the connection is intimate and reciprocal.”

Donaldson correctly points out that, while abstract thought (she calls it “disembodied thinking”) calls for the ability to step back from life, it yields its

greatest results when linked to doing. The whole history of the Renaissance is proof of this assertion. True, the field of modern science is infinitely more vast and complicated than at that time, but does this really mean that it is impossible for scientists to learn from different disciplines? Rather than being a result of the increasing complexity of the subject, is the present state of intellectual apartheid not a product of the way present society is structured, and the attitudes, prejudices, and material interests which flow from it, and seek at all costs to preserve it?

Reactionaries try to justify the present state of affairs by the now obligatory references to genetic determinism: if some of “us” are clever, and have good jobs and large salaries, that is because we were born under a lucky star (read “*with the right genes*” — it comes out about the same). The fact that the rest of humankind are not so fortunate must be because there is something wrong with their genes. Answering this rubbish, Donaldson writes:

Are only a few of us able to learn to move beyond the bounds of human sense and function successfully there? I doubt it. While it may make some sense to postulate that we each possess some genetically determined “intellectual potential,” in which case individuals will surely differ in this respect as in others, there is no reason to suppose that most of us — or any of us for that matter — manage to come close to realizing what we are capable of. And it is not even certain that it makes a great deal of sense to think in terms of upper limits at all. For, as Jerome Bruner points out, there are tools of the mind as well as tools of the hand — and in either case the development of a powerful new tool brings with it the possibility of leaving old limitations behind. In a similar vein, David Olson says: “Intelligence is not something we have that is immutable; it is something we cultivate by operating with a technology, or something we create by inventing new technology.”⁵⁰

The great Soviet educationalist Vygotsky did not believe that the teacher should operate a rigid control over exactly what the child learns. Like Piaget, he considered activity by the children as central to education. Instead of chaining children to desks, where they mechanically go through the motions of learning things which are meaningless to them, Vygotsky stressed the need for genuine intellectual development. This, however, cannot be considered in a social vacuum. In a genuinely socialist society, education would be linked with creative practical activity from the beginning, thus breaking down the stultifying barrier between mental and manual labor. In many ways, Vygotsky was ahead of his time. His educational methods showed great imagination, for example, in allowing the children to learn from each other:

Vygotsky advocated using a more advanced child to help a less advanced child. For a long time this was used as a basis of egalitarian Marxist education in the Soviet Union. The socialist rationale was one of all children working for the general good rather than the capitalist one of each child trying to get out of school as much benefit as he can without putting anything back into it. The brighter child is helping society by helping the less able one, since the latter will (it is hoped) be more of an asset to society as a literate than as an illiterate adult. Vygotsky argued that this act is not necessarily one of self-sacrifice on the part of the more advanced child. By explaining and helping the other child, he may well gain a greater explicit understanding of his own learning, on metacognitive lines. And, by teaching a topic, he consolidates his own learning.⁵¹

A democratic socialist society would abolish the difference between mental and manual labor through the general increase in the cultural level of society. This is closely linked to a reduction in the working day as a consequence of a rational plan of production. Education will be transformed by combining learning with creative activity and play. The development of all kinds of new techniques will be used to the full. V. R. (virtual reality) devices, which are at present little more than novelties, have tremendous potential, not only for production and design, but for education. This will make lessons come to life, stimulating the imagination and creativity of children, not just to experience history and geography, but to learn mechanical engineering, or how to paint and play musical instruments. Freedom from the humiliating struggle for the necessities of life, access to culture and the time to develop oneself as a human being, these are the bases upon which human society can realize its full potential.

Humanity and the Universe

He said, "What's the time? Leave Now for dogs and apes! Man has Forever." (Robert Browning, *A Grammarian's Funeral*.)

The achievements of the Soviet and American space programs provided just an inkling of what would be possible. But the space programs of the great powers were really a by-product of the arms race during the Cold War. Since the collapse of the Soviet Union, the question of space travel no longer occupies the center stage, although there is still the possibility of building a space station which will orbit the earth, making travel to the moon a lot easier. In the future world socialist commonwealth, space travel will cease to be the stuff of science fiction, and become a fact of life, as common as air travel is now. The exploration of the solar system, and later other galaxies, will provide the same kind of

challenge and stimulus to humankind as that which came to Europe from the discovery of America.

The possibility of long distance space travel beyond the confines of our own solar system will not forever remain in the realms of science fiction. Let us not forget that only a hundred years ago, the idea of flying faster than the speed of sound seemed beyond the bounds of credibility, let alone traveling to the moon. The history of the human race in general, and that of the last 40 years in particular, shows that there is no problem too great that men and women cannot solve, given time.

In about four billion years from now, our sun will begin to swell in size, as its helium core slowly shrinks. The planets near the sun will be subjected to unimaginable temperatures. Life on earth will become impossible, as the oceans boil away, and the atmosphere is destroyed. Yet the end of life in one small corner of the universe is not the end of the story. Even as our star dies, other stars will be born. Among the billions of galaxies in the visible universe, there are a vast quantity of suns and planets like our own where the conditions for life exist. Beyond doubt, many of these will be inhabited by advanced forms of life, including thinking beings like ourselves. Very few scientists now doubt this proposition, and fewer still since the complicated molecules needed to create living organisms have been found even in space itself.

At the end of *The Dialectics of Nature*, Engels expresses a vibrant optimism about the future of life:

It is an eternal cycle in which matter moves, a cycle that certainly only completes its orbit in periods of time for which our terrestrial year is no adequate measure, a cycle in which the time of highest development, the time of organic life and still more that of the life of beings conscious of nature and of themselves, is just as narrowly restricted as the space in which life and self-consciousness come into operation; a cycle in which every finite mode of existence of matter, whether it be sun or nebular vapor, single animal or genus of animals chemical combination or dissociation, is equally transient, and wherein nothing is eternal but eternally changing, eternally moving matter and the laws according to which it moves and changes.

But however often, and however relentlessly, this cycle is completed in time and space; however many millions of suns and earths may arise and pass away, however long it may last before, in one solar system and only on one planet, the conditions for organic life develop; however innumerable the organic beings, too, that have to arise and to pass away before animals with a brain capable of thought are developed from their midst, and for a short span of time find conditions suitable for life, only to be exterminated later without mercy — we have the certainty that matter remains eternally the same in all its transformations, that none of its attributes can ever be lost, and therefore, also, that with the same iron necessity that it will exterminate

on the earth its highest creation, the thinking mind, it must somewhere else and at another time again produce it.⁵²

Now, however, we are entitled to go further than this. The staggering advances of science over the hundred years since Engels died mean that the death of the sun will not necessarily mean the death of the human race. The development of powerful spacecraft, capable of traveling at speeds which at present seem impossible, could prepare the ground for the ultimate adventure, involving emigration to other parts of the solar system, and, eventually, other galaxies. Even at one percent of the speed of light — a clearly attainable goal — it would be possible to reach inhabitable planets in the course of a few hundred years.

If this seems a long time, we should remember that it took early humans millions of years to colonize the world, setting out from Africa. Moreover, the journey would probably take place in stages, establishing colonies and staging-posts along the way, like the early Polynesian settlers who colonized the Pacific, island by island, over several centuries. The technological problems will be immense, but we will have at least three billion years to resolve them. If we consider that *Homo sapiens* has only been in existence for about 100,000 years, that civilization has only existed for about 5,000 years of that, and that the pace of technological advance has tended to increase ever more rapidly, there is no reason whatever to draw pessimistic conclusions about the future of humanity — on one condition: that class rule, that atrocious relic of barbarism, is replaced by a system of co-operation and planning, which will unite all the resources of the globe in one common cause.

Engels described socialism as humanity's leap from the realm of necessity into the realm of freedom. For the first time, it will be possible for the majority of humankind to escape from the humiliating struggle for existence, and raise their sights to a higher level. The elimination of disease, illiteracy and homelessness in themselves important aims, will only be the starting point. By combining all the resources of the planet which are now being shamelessly squandered, humankind can literally reach out to the stars.

Last, but not least, humans will at last become masters of themselves, their lives, their destinies, even their genetic make-up. The relations between men and women will be relations between free human beings, not slaves. Aristotle pointed out that man begins to philosophize when the needs of life are provided. That mighty thinker understood that the development of culture was closely linked to the material conditions of life. In a truly remarkable passage, he shows

how men and women begin to philosophize, to dedicate themselves to the pursuit of knowledge for its own sake, only when they are freed from the need to struggle for the necessities of existence:

This is shown by the actual course of events; for philosophy arose only when the necessities and the physical and mental comforts of life had been provided for. Clearly, therefore, Wisdom is desired for no advantage extrinsic to itself; for just as we call a man free who exists for himself and not in the interests of another, so philosophy alone of the sciences is free since it alone is pursued for its own sake.⁵³

For the whole history of civilization to the present day, culture has been a monopoly of a small minority. In a genuinely democratic socialist society, it would be possible to ensure a general reduction in the working day, and increased living standards for everyone on the basis of a tremendous upswing of production. Freed from the pressures of necessity, men and women can devote their lives to a full and all-round development of their personality, intellect and physique. Art, literature, music, science and philosophy will occupy a similar position as party politics at present.

On the basis of a rational democratically-run planned economy, the colossal potential of science and technique could be placed at the disposal of humankind. In the last 100 years, improved diet and medical care have doubled the life-expectancy in many industrialized countries. Further improvements in life-style could prolong active life still further. To live a fully active life for a hundred years would be commonplace. The proper use of genetic engineering could even permit scientists to counteract the ageing process and prolong life far beyond what was regarded as "*man's natural span*." The possibilities for the future of humankind will be as limitless as the universe itself.

The blind elements have settled most heavily in economic relations, but man is driving them out from there also, by means of the Socialist organization of economic life. This makes it possible to reconstruct fundamentally the traditional family life. Finally, the nature of man himself is hidden in the deepest and darkest corner of the unconscious, of the elemental, of the sub-soil. Is it not self-evident that the greatest efforts of investigative thought and of creative initiative will be in that direction? The human race will not have ceased to crawl on all fours before God, kings and capital, in order later to submit humbly before the dark laws of heredity and a blind sexual selection! Emancipated man will want to attain a greater equilibrium in the work of his organs and a more proportional developing and wearing out of his tissues, in order to reduce the fear of death to a rational reaction of the organism towards danger. There can be no doubt that man's extreme anatomical and physiological disharmony, that is, the extreme disproportion in the growth and wearing out of organ and tissues, give the life instinct the form of a pinched, morbid and

hysterical fear of death, which darkens reason and which feeds the stupid and humiliating fantasies about life after death.

Man will make it his purpose to master his own feelings, to raise his instincts to the heights of consciousness, to make them transparent, to extend the wires of his will into hidden recesses, and thereby to raise himself to a new plane, to create a higher social biologic type, or, if you please, a superman.

It is difficult to predict the extent of self-government which the man of the future may reach or the heights to which he may carry his technique. Social construction and psycho-physical self-education will become two aspects of one and the same process. All the arts — literature, drama, painting, music and architecture will lend this process beautiful form. More correctly, the shell in which the cultural construction and self-education of Communist man will be enclosed, will develop all the vital elements of contemporary art to the highest point. Man will become immeasurably stronger, wiser and subtler; his body will become more harmonized, his movements more rhythmic, his voice more musical. The forms of life will become dynamically dramatic. The average human type will rise to the heights of an Aristotle, a Goethe, or a Marx. And above the ridge new peaks will rise.⁵⁴

NOTES PART FOUR

1 Aristotle, *Metaphysics*, pp. 120, 251 and 253.

2 T. Hobbes, *Leviathan*, p. 14.

3 A. Hooper, *Makers of Mathematics*, pp. 4-5.

4 Engels, *Anti-Dühring*, p. 154.

5 B. Hoffman, *The Strange Story of the Quantum*, p. 95.

6 A. Hooper, *Makers of Mathematics*, p. 237.

7 Engels, *The Dialectics of Nature*, pp. 341-2.

8 Hegel, *The Science of Logic*, p. 257.

9 Engels, *Anti-Dühring*, p. 63.

10 Quoted in T. Ferris, op. cit., pp. 521-2 and 522-3.

11 I. Stewart, op. cit., p. 63.

12 Quoted in J. Gleick, op. cit., p. 80.

13 J. Gleick, op. cit., p. 46.

14 Ibid., p. 94.

15 Ibid., p. 94.

16 Engels, *Anti-Dühring*, p. 16.

17 Gleick, op. cit., p. 86.

18 Engels, *The Dialectics of Nature*, p. 31.

19 Gleick, op. cit., p. 31, 5, 11 and 61-2.

20 Engels, *Anti-Dühring*, pp. 24-5.

21 Gleick, op. cit., p. 115.

22 Engels, *Anti-Dühring*, p. 29.

23 I. Prigogine and I. Stengers, op. cit., pp. 252-3.

- 24 J. Gleick, op. cit., pp. 6, 18-9 and 23.
- 25 I. Stewart, *Does God Play Dice?* p. 21.
- 26 Quoted in M. Waldrop, *Complexity*, p. 81.
- 27 E. Lerner, *The Big Bang Never Happened*, p. 155.
- 28 J. Gleick, op. cit., p. 115.
- 29 D. Bohm, op. cit., p. 32.
- 30 MESW, Vol. 3, pp. 339-340.
- 31 Quoted in M. Waldrop, op. cit., p. 81.
- 32 Quoted in E. Lerner, op. cit., p. 128.
- 33 Engels, *Anti-Dühring*, p. 31.
- 34 Engels, *The Dialectics of Nature*, pp. 185-6.
- 35 T. Dobzhansky, *Mankind Evolving*, p. 138.
- 36 Engels, *Anti-Dühring*, pp. 45-6.
- 37 Ibid., p. 24.
- 38 B. Hoffmann, op. cit., p. 210.
- 39 Quoted in I. Stewart, op. cit., p. 40.
- 40 M. Waldrop, op. cit., p. 48.
- 41 S. J. Gould, *The Panda's Thumb*, pp. 153 and 154.
- 42 Gleick, op. cit., p. 76.
- 43 W. Rees-Mogg and J. Davidson, op. cit., pp. 294-5, 183 and 273.
- 44 J. K. Galbraith, *The Culture of Contentment*, pp. 170-1.
- 45 MESW, Vol. 1, pp. 114-5.
- 46 MECW, Vol. 4, p. 274.
- 47 Trotsky, *Their Morals and Ours*, p. 13.
- 48 Marx, *Grundrisse*, p. 111.
- 49 Quoted in Gleick, op. cit., pp. 116-7.
- 50 M. Donaldson, *Children's Minds*, pp. 83 and 85.
- 51 P. Sutherland, *Cognitive Development Today: Piaget and his Critics*, p. 45.
- 52 Engels, *Dialectics of Nature*, p. 54.
- 53 Aristotle, op. cit., p. 55.
- 54 Trotsky, *Literature and Revolution*, pp. 255-6.

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GLOSSARY OF TERMS

Please note that this glossary is not intended, for reasons of space, to be exhaustive. To avoid repetition, terms explained in the text are not generally included here.

Adaptive radiation - Evolution, from a primitive type of organism, of several divergent forms adapted to distinct modes of life.

Allopatric Theory - The theory that the evolutionary divergence of populations into separate species, which no longer interbreed, takes place in geographically separate places

Amino Acids - Organic compound containing both basic amino and acidic carboxyl groups. Amino acid molecules combine to make protein molecules and are therefore a fundamental constituent of living matter.

Causality, Law of - The law defining the interdependence of cause and effect - the necessary connections between phenomena. Causality is an essential question in the struggle between materialism and idealism.

Chromosomes - A chain of genes found in cells. They are present in all cells in the body and consist of DNA and a supporting structure of protein.

Cognition - The process by which human thought reflects and observes the real world.

Convergent Series - Number series in which the successive partial sums obtained by taking more and more terms approach some fixed number or limit.

Cytoplasm - All the protoplasm of a cell excluding the nucleus.

Determinism - A belief that all processes are predetermined by definite causes and natural laws and can therefore be predicted. Biological determinism and mechanical determinism are two variations of this premise. Indeter-

minism is the reverse of this - a belief that events are governed not by laws but by pure chance.

Dialectics - From the Greek words for dispute and debate, this is the science of the general laws governing the development of nature, science, society and thought. It considers all phenomena to be in movement and in perpetual change. Marxism linked this concept to materialism and showed the process of development in all things through struggle, contradiction and the replacement on one form by another.

Diploid - Cell with chromosomes in pairs. DNA - The molecule that carries the genetic information in organisms (except RNA viruses).

Dogma - A blind belief in things often without a material base.

Eclecticism - A mechanical and/or arbitrary collecting of concepts or facts without any pre-established principles or structures. Eclecticism is often used to attempt to reconcile the irreconcilable such as idealism and materialism.

Electrons - Elementary particles that possess one unit of negative charge and are a constituent of all atoms.

Entropy - One of the main notions of thermodynamics, where it is normally viewed as a measure of disorder. In isolated systems, it is used to determine the way in which the system will change if heated or cooled, compressed or expanded. Thermodynamics holds that the entropy of a system can never decrease but only increase and that a state of maximum entropy is marked by a state of balance in which no further conversion of energy is possible. This has been used to justify the erroneous idea of the "heat death of the universe." In recent years, I. Prigogine has reinterpreted the Second Law of Thermodynamics in a way which defines entropy differently. According to Prigogine, entropy does not mean higher disorder in the generally accepted sense, but an irreversible process of change which generally leads to more highly ordered states.

Empiricism - A teaching on the theory of knowledge which holds that sensory experience is the only source of knowledge and affirms that all knowledge is founded on experience and is obtained through experience. The opposite to rationalism. The main failing of this is a tendency to reject reason as a means of deduction in favor of a metaphysical exaggeration of the role of experience alone.

Electromagnetism - The study of the effects of the relationship and interplay between a magnetic field and an electric current. For example the electrical creation of a magnetic field in a conductor.

Eugenics - A doctrine which holds that the human race can be "improved" by selective control of breeding to eradicate less "desirable" traits in society.

- The supporters of eugenics argue that social problems are caused by inherited genetic traits in people which can be bred out to resolve the problem for future generations. The logical conclusion of this theory is deeply racist and reactionary based on dubious research and prejudice.
- Eukaryotes - One of the two major groups of organisms on Earth (the other being Prokaryotes). Characterized by the possession of a cell nucleus and other membrane-bounded cell organelles.
- Gene - A unit of heredity; a sequence of base pairs in a DNA molecule that contains information for the construction of protein molecule.
- Genome - The entire collection of genes possessed by one organism.
- Genotype - Genetic constitution (the particular set of alleles present in each cell of an organism) as contrasted with the characteristics manifested by the organism.
- Gradualism - The theory that all evolutionary change is gradual rather than occurring in leaps and jumps.
- Haploid - Cell with single set of chromosomes.
- Lamarckism - The theory that acquired characteristics can be inherited and that any new genetic variation tends to be adaptively directed rather than 'random' as stated by Darwin.
- Logical Positivists - A variation on positivism which attempts to combine subjective-idealist empiricism with a method of logical analysis.
- Lysenkoism - A revival of Lamarckism in the USSR under Lysenko who sought to affect the hereditary modification of plants by certain treatments. his research was subsequently discredited but was heavily touted by Stalinists in its day.
- Malthusian Theory - The theory developed by Thomas Malthus which claimed that population levels were responsible for social problems and should be checked to resolve them since uncontrolled population increases occur on a geometrical ratio whereas the increase in resources occurs on an arithmetical basis. This is not so but laid the basis for the belief that nothing could be done about the problems of the world. In its most extreme form it was the basis for an acceptance of famines etc. as unavoidable and socially necessary.
- Meiosis - Cell division in which a cell gives rise to daughter cells with half as many chromosomes.
- Metaphysics - There are two definitions of this word: the one used by Marx and Engels, and the other more traditional conception. In Marxist terminology, metaphysics is a method which holds that things are final and immutable, independent of one another and denies that inherent contradictions are the source of the development of nature and society but rather that nature is at

rest, unchanging and static. All things can be investigated as separate from each other. Nowadays, the word reductionism would often be used instead.

The more traditional philosophical definition derives from Aristotle who used the word metaphysics to describe the branch of philosophy dealing with universal concepts as opposed to the observation of nature (in Greek, "meta ta physika" means "that which comes after physics"). Later on it became a synonym for abstract idealist speculation.

Mitosis - Cell division in which a cell gives rise to daughter cells with a complete set of chromosomes.

Monad - A primary organic unit. A chemical element having a valency of one. The monad played a central role in the idealist philosophy of Leibniz.

Mutation - An inherited change in the genetic material; a change in the genotype

Neutrons - One of the two types of particle which form the nucleus of an atom - the other being the proton.

Nodes - The points in a wave system where the amplitude of the wave is zero. In Hegel, the nodal line of measurement was one where the line is interrupted by sudden leaps, denoting qualitative change ("node" here means "knot").

Nucleotide - A biochemical molecule used as the basic building block of DNA and RNA.

Paleontology - The study of fossils and other records of ancient life.

Phenotype - Manifested attributes of an organism (e.g., eye color).

Photon - Units or 'packets' of electromagnetic radiation.

Plasma - A gas that contains a large number of positively and negatively charged particles (ions and electrons). This can occur when a gas is raised to extremely high temperatures (e.g., the outer regions of the sun) or in an intense electrical field. Plasma physics is an important branch of modern science.

Polymorphism - The coexistence of several well-defined distinct phenotypes or alleles in a population.

Positrons - The antiparticles of electrons - having the same mass but a positive charge.

Positivism - An idealistic current which believes in "positive" facts rather than abstract deductions. It denies that philosophy is a world outlook and states that belief should be concentrated on a description of facts rather than an analysis of them. Positivism claims to be neutral and above philosophical outlooks, interested in processes but not willing to go beyond the boundaries of the status quo. In effect they confirm the maintenance of existing social structures.

- Prokaryotes - One of the two major groups of organisms on Earth (the other being Eukaryotes). They have no structured cell nucleus and no membrane-bounded organelles.
- Proton - One of the two types of particles which form the nucleus of an atom - the other being neutrons.
- Protoplasm - Substance within and including plasma-membrane of a cell or protoplasm.
- Quantum Mechanics - The mathematical description of the workings of the atomic and sub-atomic structures.
- Quark - According to particle physics these sub-atomic particles are believed to be the constituents of elementary particles known as hadrons. Five or possibly six different sorts are thought to exist, but new discoveries are being made all the time.
- Quasars - Quasi-stellar radio sources (quasars) were first detected by virtue of their radio transmissions and appear to show the small bright centers of distant galaxies (although some believe that they are not as far away as people imagine but are moving at high speeds).
- Rationalism - The theory which holds that reason is the unique source of knowledge as against empiricism which holds that perception is the source of knowledge.
- Reductionism - A belief that all scientific laws and processes relating to complex systems can be reduced down to basic scientific laws. Physicalism was a version of this.
- Relativity, Theory of - The laws of relativity (relationship between an object and an observer or another object) considered and developed by Einstein. Einstein's general theory deals with motion, gravity, time and the concept of curved space. The theory which deals with constant velocities is called the special theory. The most famous part of these laws is that which shows the relationship between mass and energy ($E = mc^2$).
- Speciation - The process of evolutionary divergence i.e., two species being produced from one source.
- Stasis - A period in which no evolutionary change takes place in the development of a species.
- Sufficient Reason, Law of - A principle that holds that a proposition can only be considered true if sufficient reason for it can be formulated.
- Syllogism - A doctrine of inference, historically the first logical system of deduction, formulated by Aristotle. Every syllogism consists of a triad of propositions: two premises and a conclusion.
- Systematics - Study of the diversity of organisms.
- Taxonomy - Study of classifying organisms.

Thermodynamics - The branch of physics concerned with the nature of heat and its transformations. The First Law of Thermodynamics is generally referred to as the Law of the Conservation of Energy. The Second Law deals with the concept of increasing entropy (see under entropy).

